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James Rennell Centre
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INTERNAL DOCUMENT No. 17

The SWALES Experiment -
Field Phase Summary

P K Taylor (Ed.)

1994

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1. INTRODUCTION

1.1 Experiment Aims

The SWALES experiment was conducted under Commission FD0603 from the Flood and Coastal Defence Division of MAFF, the "Validation of a Wave-Tide-Surge Model". The specific experiment aims were as follows:

I To aid development of the Wave Tide Surge model at the Proudman Oceanographic Laboratory (POL): to collect wind stress and meteorological data from the Sonic Buoy together with simultaneous directional wave spectra, surface current, and current profile data under a wide range of weather conditions. The data will be used to compare the alternative surface stress formulation(s) from the experiment with modelled formulations. The Bristol Channel area was chosen because of the poor performance of the present Tide-Surge model in that region which has led to the development of a 'Local' Tide-Surge model (Flather, 1993)

II To allow the data to be compared to our main wind stress data set: wind stress and meteorological measurements were required from a ship stationed near to the Sonic Buoy during a representative range of weather conditions.

1.2 Experiment Components

The main experiment components of the SWALES experiment field phase were:

- A moored buoy array in Carmarthen Bay, 51° 29.5'N 4° 45'W (Figure 1.1) in 40m to 50m water depth depending on tide,. The array (Figure 1.2). consisted of the IOSDL Sonic Buoy, a Datawell Directional Waverider, an IOSDL VAESAT buoy; and an IOSDL Mean Meteorology buoy. The position of the buoys within the array is shown in Figure 1.3.
- A shipboard measurement programme using instruments mounted on the RMAS Warden (Figure 1.4). A Sonic anemometer and psychrometers were mounted on the IOSDL 10m meteorological mast in the ship's bow.
- Shore-side support activity in S. Wales. A receiving station for the radio link from the Sonic Buoy was sited in Manorbier. The buoy systems were prepared, and the backup moorings stored, at the Pembroke Dockyard.
- Shore-side support activity at IOSDL and JRC. The ARGOS satellite transmissions from the buoy array were monitored at JRC to check that the buoys were in position and providing good data. The Meteosat satellite transmissions from the Sonic Buoy were monitored at IOSDL. Mooring recovery and servicing were organised from IOSDL.

The data transmission and data recording details for each instrument system are summarised in Table 1.1.

Platform	Recording/Transmission	Variables
Sonic Buoy	Internal recording	Mean wind speed and direction, air temperature, sea temperature, buoy orientation; smoothed wind spectra; buoy motion (selected samples)
	ARGOS satellite	Position, Wind spectral level, mean wind speed.
	Meteosat satellite (2nd deployment only)	Mean wind speed and direction, air temperature, sea temperature, buoy orientation, battery volts
	RF link to shore	Raw data from Sonic anemometer
VAESAT	Internal recording	EM current meter: east and north components (mean and RMS) Compass: buoy orientation. ADCP : Amplitude, gain, east and north components
	ARGOS satellite	EM current meter and compass data
S4 Current Meter (beneath VAESAT)	Internal recording	East and north current components.
DWR	Internal recording	Wave spectra, SST, housekeeping.
	ARGOS satellite	As internal recording
Met. Buoy	Internal recording	Mean wind speed, Gust wind speed, Wind direction, Buoy orientation, air temperature, sea temperature.
	ARGOS satellite	Position fixes only (failed)
Aanderaa Current Meters (beneath Met buoy)	Internal recording	Sea temperature, depth, east and north components
RMAS Warden	Onboard recording	MultiMet: Mean wind speed and direction, air temperature, SST (when deployed) GPS system: ship's head and position Sonic Anemo: Spectra and raw data.

Table 1.1 Summary of variables transmitted and/or recorded by the SWALES instrument systems.

1.3 Contingency plans

Notices to Mariners were issued with regard to the mooring array and each buoy carried a warning light. However it was recognised that there was a possibility of moorings being run down, cut free by fishing, or going adrift in rough weather. The operational plan allowed for a primary set of moorings to be deployed and a backup set to be kept in sheds at Pembroke ready for quick deployment if required. For full details of the monitoring and contingency planning see section 4.6.

1.4 Personnel

1.4.1 Instrumentation

Keith Birch	Experiment Manager - logistics, organisation, costing; Instrumentation.
Robin Pascal	Sonic Buoy Project Manager - Instrumentation.
Charles Clayson	Systems engineer/analyst - Satellite links, Instrumentation.
Nick Crisp	VAESAT buoy
Paul Smith	Instrumentation: Sensor preparation and calibration

1.4.2 Moorings

Ian Waddington	Mooring team leader - Moorings, Met. Buoy.
Keith Goy	Moorings, Met. Buoy.
Mark Hartman	Mooring recovery
Moss Aldridge	Mooring deployment

1.4.3 Science

Peter Taylor	Meteorological Team Leader
Margaret Yelland	SWALES Science Manager
Elizabeth Kent	ARGOS monitoring
Simon Josey	ARGOS monitoring

2. NARRATIVE

2.1 Mobilisation (days 275 to 293).

In preparation for the SWALES measurement period a Shore Station was established at Hill Farm, Manorbier, near Tenby. A weather proof wooden shed was erected on 2nd October 1993 (day 275) and a mains electrical supply was connected from the adjacent farm buildings by a qualified electrical contractor (day 282).

Equipment was loaded at IOSDL on Tuesday 12th October (day 285) and transported to Pembroke using a 40 foot articulated lorry and a 7 ton self-drive truck. Preparation of the moored systems commenced at H.M. Mooring & Marine Salvage Depot in Pembroke on 13th October 1993, (286). Over a three day period, testing was completed for the Sonic Buoy, a Directional Waverider (DWR), and a Vector Averaging Electromagnetic Satellite Buoy (VAESAT). Instrumentation checks were also made on the spare buoys, which were to be held at Pembroke ready for deployment in event a mooring failure; these were a further VAESAT and DWR, and the Mean Meteorological Buoy. Recording was started on all the buoy systems internal loggers and data checks were made by phone to colleagues monitoring the satellite transmission of data via Argos and Meteosat at Wormley. All systems were successfully commissioned except for the Meteosat transmitter which was removed from the Sonic Buoy due to a power supply failure.

At the Shore Station, the receiving equipment was commissioned, with the aerial erected on the hill about 100m due south of the shore station building. The mast was deployed fully extended, which gave a clear line of sight for the aerial to the mooring site. To provide some protection from the prevailing wind direction the mast was deployed on the northern lee side of the cliff top.

On board the RMAS Warden, fabrication of a metal base was completed on the morning of day 293 to enable the IOS 10m Meteorological Mast to be mounted in the ship's bow. Also over the period the days 292-293 the MultiMet, Wind Stress and Navigation Recording systems were fitted on a bench in the aft section of the bridge, with the necessary cabling installed between the sensors and the recording systems.

2.2 Initial Mooring Deployment (day 293)

RMAS Warden sailed at 1100Z on day 293; IOSDL personnel on board were Moss Aldridge, Keith Goy, Robin Pascal, Ian Waddington and Margaret Yelland. While the vessel was on passage to the mooring site, Keith Birch and Charles Clayson monitored the reception of radio signals from the Sonic Buoy at the Shore Station in order to determine the receiving aerial beam width. Deployment of the Sonic Buoy was completed at 1408Z/293, the VAESAT (with S4 current meter beneath) at 1455Z/293, and the Waverider at 1522Z/293. The Warden then 'hove to' near the moorings making inter-comparison measurements with the ship's systems. Failure of the acoustic release systems during preparation prevented deployment of the planned sub-surface current meter mooring. The ship completed the passage back to Pembroke docking at 2130Z/293.

During the morning of day 294, equipment used during the mooring deployment was removed from the Warden, and data collected during the inter-comparison period was copied from the onboard data systems. The shore station was visited at midday to check the operational status of the data link and to copy the data collected since the Sonic Buoy had been deployed.

2.3 First Sonic Buoy Deployment Period (days 293 to 316)

For the duration of the experiment period the ARGOS data were checked (in rota by Simon Josey, Elizabeth Kent, Peter Taylor and Margaret Yelland) to ensure that the buoys were on position and that the data appeared to be of good quality. Checks were performed twice a day, morning and evening, by connections over the PSS network to the ARGOS computers. The data was copied to a terminal and processed by software to decode the message format into geophysical units. The buoy status was confirmed by phone to the Duty Officer (Keith Birch, Charles Clayson, Robin Pascal, in rota) who had the responsibility to initiate action should a mooring problem occur. A program of routine visits to Pembroke was scheduled on a weekly basis to check the Shore Station and the systems installed on the RMAS Warden.

On day 300, a phone call was received at IOS from the fishing boat Ailsea, which reported that it had fouled it's nets at the Waverider mooring. After discussion the skipper decided to buoy off his nets to allow their recovery after the moorings were cleared. To check the state of the Waverider mooring, RMAS Scarab sailed from Pembroke at 0900Z/302 with Ian Waddington onboard, arriving at the mooring site at 1155Z/302. Visual inspection of the Waverider showed that it was floating correctly, with the bungee mooring occasionally visible. The sea state precluded launch of the work boat, therefore no attempt could be made to recover the Waverider or the fishing floats. Elizabeth Kent, Peter Taylor, and Margaret Yelland made a routine visit to the Shore Station during the afternoon of day 301, and serviced the ship systems on the RMAS Warden during day 302, meeting Ian Waddington at the dock.

A routine data collection visit was made to the Shore Station by Peter Taylor on the afternoon of day 309 to copy the anemometer raw data. During the evening, data was copied from the shipboard systems on RMAS Warden. An uninterruptable power supply was fitted to the recording systems to alleviate problems of clock corruption when the ship switched between on-board and shore-side electrical power. The following day the RMAS Warden sailed at 0900Z/310 with Moss Aldridge, Peter Taylor, and Ian Waddington on board with the aim of collecting inter-comparison data, deploying the Mean Meteorological Buoy with current meters as part of the mooring, and to check the moorings, particularly the state of the Waverider. The decision to deploy the Mean Meteorological Buoy was taken because of the failure of Meteosat transmissions from the Sonic Buoy. There was a danger that, should the Sonic Buoy be lost during the experiment, no mean meteorological data would be available. Data analysis at the JRC had shown that the air temperature might be recovered from the speed of sound information from the sonic anemometer which was being logged at the Shore Station but that the calibration would be dubious. SST was being transmitted from the DWR, but there was no source of wind direction data other than that recorded on the Sonic Buoy. For these reasons it was decided to deploy the Mean Meteorological buoy, using it as a surface marker for the current meter mooring which had not been originally deployed due to failure of the release systems.

On arrival at the mooring array it was observed that the Waverider was floating low in the water possibly because the mooring had by now been fouled by the buoyed off fishing nets. At

1225Z/310 Warden commenced recovery of the fishing nets, but without success due to the mooring rope supporting the nets parting under the load. At 1340Z/310 the Warden anchored and preparations were finalised for mooring the Meteorological Buoy. This deployment was completed at 1445Z/310 and the ship weighed anchor remaining near the Waverider until slack water. Whilst attempting to recover the Waverider the bungee parted, hence the buoy was recovered and re-deployed with a new mooring. This was completed at 1654Z/310. The ship then kept station downwind of the buoys collecting data for inter-comparison between the shipboard systems and the Sonic Buoy until 0355/311. Following a comparison of the GPS and ship's compass systems, the Warden left the mooring site at 0426Z/311 and steamed for Pembroke arriving at 0730Z/311. Peter Taylor made a second visit to the Shore Station at 1300Z/312 to copy data collected during the inter-comparison period whilst the Warden was at the mooring site.

The buoy array now consisted of the Sonic Buoy, DWR (on new mooring), VAESAT (with S4 current meter beneath), and the Mean Met. Buoy (acting as surface marker to the subsurface current meter mooring). The ARGOS beacon on the Mean Met Buoy failed to function properly, so position (and quality control data) were only available from the other three moorings.

On day 313 at 14.10Z the Sonic Buoy capsized in significant wave height of 4m at 6 second period. The loss of ARGOS data was noted by Simon Josey during the routine evening position check on that day and, when no further data had been received by the following morning, a phone call was made to Hill Farm who confirmed that the Shore Station was no longer receiving data. The recovery procedures were instigated through the IOS mooring team and arrangements were made through Pembroke Dock for the use of a range patrol boat for the following day (315). While IOS staff travelled to S. Wales to recover the Sonic Buoy, the Waverider was reported 'adrift' based on the reported Argos position. Ian Waddington, Keith Goy, Keith Birch, Charles Clayson, and Robin Pascal were collected from Tenby harbour at 1200Z/315 by the range patrol boat Halifax and proceeded to the mooring site. Because of constraints imposed by the sea state and the patrol boat capabilities, recovery of both the Sonic Buoy and Waverider was not possible during remaining daylight. After location of the capsized Sonic Buoy, a skilled operation enabled the buoy to be cut free from the mooring. The buoy was then righted and towed to Tenby, where it was craned onto the quay at 1715Z/315. In the morning of day 316 the Sonic Buoy was collected by lorry and returned to Pembroke, where the electronic systems were removed from the buoy to enable them to be checked.

After a delay waiting for the Gonio Argos direction finder to be delivered by overnight carrier to Tenby, the RMAS Falconet sailed at 13.00Z/316, again with IOS staff, to locate and recover the Waverider. This was achieved using position predictions based on ARGOS tracking of the buoy at the JRC and by the use of the Gonio radio direction finder.

2.4 Sonic Buoy refurbishment (days 316 to 325)

During the period 316 to 325, only the Mean Meteorological Buoy and the VAESAT buoy remained at the mooring site. At Pembroke dockyard, modifications were made to the Sonic mooring design, the Sonic Buoy electronics systems were checked and the Meteosat transmitter power supply was repaired. All the wind sensors, including the Sonic anemometer, had been destroyed by the capsize and immersion and had to be replaced. The ship systems on the RMAS Warden were serviced on day 317 and the Shore Station data up to and including the time of the capsize were down-loaded on day 321.

2.5 Second Sonic Buoy Deployment Period (days 326 to 339)

The Sonic Buoy and Waverider were prepared for re-deployment on day 325 at Pembroke Dock. RMAS Warden left Pembroke dock at 1045Z/326 with Keith Goy, Mark Hartman and Robin Pascal on board. The Waverider Buoy was re-deployed at 1350Z/326 and the Sonic Buoy mooring completed at 1425Z/326. A cylindrical marker buoy was also deployed at the north western corner of the mooring array to provide a visual and radar reference for the array to approaching vessels. During the morning of day 327 data were copied from the land station recording system. The Warden remained at the buoy array taking intercomparison data until 1645Z/326 before returning to dock at Pembroke at 1910Z/326.

The mooring array now consisted of the Sonic Buoy, DWR, VAESAT, Mean Met buoy, and Pembroke marker buoy. The Meteosat transmission system from the Sonic Buoy was now operational providing hourly data sets to the Wormley receiving station. These data showed that the primary batteries on the Sonic Buoy were beginning to fail sooner than had been expected and preparations were made to attempt to recover the Sonic Buoy or, failing that, to mount a new Argos beacon on it. With a forecast of possibly lighter winds over night, the RMAS Warden left Pembroke at 0001Z/339 with Nick Crisp, Keith Goy, Robin Pascal and Margaret Yelland. The ship remained at the buoy array from about 0240Z/339 to 0800Z/339 collecting intercomparison data, but rough seas prevented any servicing of the moorings.

2.6 Final experiment period (days 339/93 to 017/94)

Unfortunately the Sonic Buoy primary batteries had become exhausted late on day 338; however Argos position data continued to be received until day 343. The ARGOS data showed that, following the period of extreme winds and waves on day 342, the Sonic Buoy, VAESAT and DWR were still on station and that the latter two buoys were operational. At the peak of the storm, the waves had an 11m significant wave height at 13 second period, with winds speeds of 90 knots reported from Aberporth.

With concern that neither the Sonic Buoy nor Met. Buoy could be tracked by Argos, and no knowledge of whether the latter had survived the storm, an abortive recovery attempt was initiated on day 351. IOS staff travelled to Pembroke but the weather was too bad for the ship to leave port. However the opportunity was taken to decommission the shore station.

On day 355, a phone call from Tywi Yacht Club, Ferryside, informed us that the Sonic Buoy had been washed ashore in the River Tywi estuary, with a first reported sighting in the estuary on day 350. Staff from Pembroke visited the buoy during the afternoon of day 355 and secured it to the beach. The IOS mooring team travelled to Ferryside arriving at 0800Z/356 and recovered all the buoy systems, the buoy was then man handled into the estuary and floated on a rising tide to the Yacht Club slipway, where it was recovered by crane and transported back to Pembroke.

On 6 January 1994 (day 006), a Keith Goy was collected from Tenby beach by the Grasmere and proceeded to the mooring site arriving at 1950Z/006. The VAESAT and Waverider buoys were identified by the flashing lights and grappling for the Waverider bungee was commenced. During disconnection of the two bungees the Grasmere was forced to re-position to relieve the tension and allow recovery to continue. As the recovery proceeded it became apparent that the mooring had parted, on examination this showed that the lower bungee had pulled out of its lower attachment point. As the weather was deteriorating both in the sea state, and visibility due to snow, only a limited visual search was possible for the Met Buoy and marker buoy moorings, without success. The Grasmere departed at 2030Z/006 and docked at Pembroke 0030Z/007.

Recovery of the Meteorological and VAESAT buoys were completed on day 017 by Nick Crisp, Keith Goy and Robin Pascal using the RMAS Warden. The ship left Pembroke at 0930Z/017 arriving at the buoy array at 1215Z/017. The Meteorological buoy was recovered by 1420Z/017; however during the recovery of the Aanderaa current meters the mooring parted at the top of the lower current meter, which was therefore lost. The VAESAT buoy together with the sub-surface S4 Electromagnetic current meter were successfully recovered by 1515Z/017. It also proved possible to recover the remaining mooring components of the second Sonic Buoy mooring and third Waverider mooring. The Pembroke marker buoy was located some 3 miles north of the original site and recovered by 1720Z/017. The ship docked at Pembroke at 2030Z/017.

Following this very successful recovery operation the only mooring components remaining on site comprise the lower parts of the first two Waverider moorings (which failed at the bungee termination), of the first Sonic Buoy mooring (which was lost following the capsize), and of the current meter mooring with one Aanderaa current meter (which broke during recovery). Arrangements have been made for the RMAS Warden to trawl the site to recover these debris.

3. SUMMARY OF WEATHER CONDITIONS[1]

3.1 First Sonic Buoy Deployment Period (days 293 to 316)

High pressure had become established over the UK from the 12th October (285). On day 293 the anticyclone centre extended over the North Sea, Denmark, and north Germany causing a wind flow from east northeast over the SWALES area for the first buoy deployment. The centre of the high pressure drifted slowly westwards resulting in the wind direction gradually veering with winds from the east by about day 300, and from the south by about day 306. The wind speed was about 6 to 10m/s until day 302 when the anticyclone centre was close to the SWALES area and the wind dropped below 5 m/s. The air temperature varied between 8°C to 12°C with a marked diurnal variation of about 2°C. This was significantly colder than the sea surface temperature of nearly 14°C on day 293, cooling to about 12.5°C by day 306.

On day 306 a depression to the west brought winds over 10m/s from the south and from day 307 to 310 the air temperature was similar to, and occasionally warmer than, the SST. A colder air mass was reintroduced on day 311. Wind speeds remained generally low, from 3 to 8 m/s, until on day 313 stronger winds from the southwest ahead of an occluding frontal system caused the sonic buoy to capsize.

[1] In reading this section it may prove useful to refer to the Figures which show time series plots of the data from the Sonic Buoy and Directional Waverider. These are: Figure 5.4 (p.52) Sonic Buoy, First deployment; Figure 5.5 (p.53) Waverider, First deployment; Figure 5.8 (p.56) Sonic Buoy, Second deployment; and Figure 5.9 (p.57) Waverider, Second deployment.

3.2 Sonic Buoy Refurbishment Period (days 316 to 325)

Winds from the southwest now became established over the area. The passage of a small complex depression on day 317 brought strong warm sector winds and then strong cold airflow from the north on day 318. A ridge of high pressure now became established between Scandanavia and the Azores wind winds from the south over the SWALES area. Pressure gradients were generally weak on day 326 when the Sonic Buoy and Waverider were redeployed.

3.3 Second Sonic Buoy Deployment Period (days 326 to 338)

The synoptic pattern for this period was high pressure over Scandanavia and a complex low situated in the Greenland/Iceland region. The resulting strong pressure gradient resulted in strong winds from a south to southwest direction. At the start of the deployment the winds were light and the air cold, some 6°C colder than the sea. A small depression on day 328 resulted in 13m/s winds ahead of the warm front. During the later part of day 328 and during day 329 the air was warmer than the sea and warm sector conditions with light winds occurred on day 330. A strong south to southwest flow then became established on days 331 to 333; however despite the wind direction the air was of continental origin and the air temperature was a few degrees colder than the sea. The strongest winds recorded by the Sonic Buoy, about 18m/s, occurred ahead of a warm front passage on day 333. Colder air returned during 334, but from day 335 through to day 338 the SWALES area was covered by a warm sector air flow from the west with air temperatures about a degree warmer than the sea. Slightly colder air followed a cold front on day 338, a few hours before the failure of the Sonic Buoy batteries.

3.4 Final Experiment Period (days 338/93 to 017/94)

For the remainder of the experiment period only the Waverider and VAESAT buoys were functioning. Mobile, westerly weather conditions were dominant and a continual series of depressions crossed the area preventing the Sonic Buoy from being recovered and allowing no chance to inspect the other buoys. A particularly intense depression crossed the area on day 342 with winds gusting to 45 m/s reported from Aberporth. Associated with this storm the significant wave height approached 10m with 10 seconds zero crossing period. The sea state remained rough, from 2 to 5m significant wave height, almost continuously The only significant weather window was a weak ridge of high pressure occurring on days 359 to 360, Christmas Day and Boxing Day. The Waverider was recovered on day 006/94 in a snow storm. The final recoveries took place on day 017/94 when a ridge of high pressure brought calmer conditions.

4. PROJECT REPORTS

4.1 Sonic Buoy

4.1.1 Hardware

Buoy Configuration

The buoy used during the SWALES experiment was the prototype of the IOSDL EMB30 and was configured to measure wind stress, buoy motion and mean meteorological parameters. The buoy contained 7 subsystems, each of which had internal data storage or a data transmission system. These were :-

- Mean Meteorological system
- Sonic Anemometer controller / processor
- Raw Sonic Anemometer data storage system
- VHF Transmitter system for raw sonic anemometer data
- Buoy Motion package
- Data Formatting system
- Argos / Meteosat transmission system.

The buoy consists of a 3m discus housing the electronics and batteries and a quadrapod tower with an annular ring for mounting sensors, aerials and navigation aids. The buoy is oriented into the wind by vanes which are mounted on one of the tower legs, thus ensuring good exposure of the sensors. The sensors used were:-

- Two PRT Sea Surface Temperature sensors mounted through the buoy hull.
- Two PRT air temperature sensors mounted in Vector Instruments radiation screens on the exposed front of the tower.
- Two R.M.Young AQ Wind Monitors mounted on the annular ring. One of these is used by the Buoy Motion Package and determines when the package takes measurements.
- One Solent Sonic Research Anemometer, mounted on the most exposed part of the annular ring.
- Compass for buoy orientation, logged through the Solent Sonic
- ARGOS, Meteosat and VHF transmitter aerials.

The buoy also carried a flashing yellow light, character FL(5) 20 seconds (5 flashes in 5 seconds with 15 seconds off). The buoy's ARGOS ID number was 5060.

Mooring

During the SWALES period there were two separate deployments of the Sonic Buoy and a different mooring design was used on each occasion. The first mooring used (Figure 4.1) was designed by ORCINA Ltd. The design was based on a nylon warp just over twice the water depth, which was connected to the buoy via a two leg bridle. The mooring had distributed buoyancy along the warp to reduce risk of snagging on the sea bed.

After the buoy capsized the mooring was redesigned for the second deployment (Figure 4.2). To help stabilise the buoy a 200 kg ballast weight was suspended a metre below the buoy from a three point chain bridle. Again a nylon warp was used, just over twice the water depth long, with distributed buoyancy. At the top of the mooring there were two surface buff buoys 10 m apart, these were connected to the buoy via a two leg bridle.

4.1.2 Operational History

The use of the Sonic Buoy during SWALES is summarised in Table 4.1.1.

4.1.3 Data Sources

Figure 4.3 gives an overall view of the data sources for the Sonic Buoy.

Sonic Processor EPROM Logger Data

The Sonic Processor EPROM Logger records the spectral data from the Sonic anemometer. The sonic anemometer data were acquired and processed by a modified form of the software *FFTC2*, used on RRS Charles Darwin cruise 62A, running in a DSP ECAT286 processor with maths coprocessor and IOSDL EPROM logger. The software initiated acquisition of raw data from the anemometer at 00, 15, 30 and 45 minutes past each hour, as timed by the ECAT real time clock. The anemometer was commanded to run in Mode 1, using the modified version of the *FASTCOM* software used previously. 15*1024 samples of raw data at 21 Hz were saved to the ECAT RAM Disk in a file of length approximately 153,644bytes.

The U and V components of the anemometer output were converted to North and East components, using the compass readings from the analogue input channel. They, as well as the W component, were averaged over the (approximately) 10 minute long record, to give North, East and "Vertical" vector averages. A resultant velocity (given by sqrt(U^2 + V^2 + W^2)) was calculated for each sample and these velocities were spectrally analysed in 15 sections of 1024 samples. The spectral processing involved three stages: subtracting the mean value over the section, applying a partial cosine window to the data, and applying a Fast Fourier Transform algorithm to the windowed data. Finally the 15 sections were converted to energy, averaged and corrected for windowing loss. The spectrum at this point consists of 256 energy estimates. These were converted to log10(power spectral density*frequency^5/3) and the resulting estimates were written to the EPROM logger, together with header information and parameterised data including mean wind speed, vector averages, mean power spectral density over frequency range 2 to 4 Hz, and a linear fit to the f^5/3 spectrum over this range.

Before all deployments the EPROM logger was completely erased to give the maximum storage capacity of 16 Mbytes. After each deployment, the EPROM data was replayed on to a PC as a hexadecimal ASCII file with two hex characters per byte . This was decoded into readable ASCII by the QBASIC program DECODE.SON. The data has been transferred on to Magneto Optical Disk.

During the second deployment there was a problem with the Sonic Processor Clock, causing it to jump a number of times during the deployment. The data time stamps will therefore have to be corrected by comparison to the formatter data and clock. During the first deployment the data started at 1615Z/286 and ended at 1345Z/313. For the second deployment the data start at 1330Z/325 and end at 2015Z/338 (corrected time).

Day	Operation
285	The Sonic Buoy with its pallet was sent by lorry from IOSDL to Pembroke Dock
286	Arrived Pembroke Dock
286 to 288	Preparation and assembly in the Pembroke H.M. Moorings and Salvage hanger.
288 to 291	under test outside, powered by one battery pack.
291	The full complement of 5 battery packs were added to buoy, replacing the battery pack used while the buoy was under test.
292	The systems were rechecked prior to deployment, the Meteosat battery charger was found to be faulty. The Meteosat system was removed from the buoy. The VHF receiving station was installed at the shore station at Hillside Farm Tenby.
293	Buoy deployed from RMAS Warden at 14:08 hrs.
313	VHF and ARGOS transmissions not received from buoy. Buoy capsized.
315	Buoy recovered by using the range boat RMAS FALCONET and towed to Tenby harbour.
316	Buoy loaded on lorry and transported back to Pembroke Dock. The buoy's subsystem modules were returned to IOSDL and the data replayed.
321	VHF receiver still waiting for more data after buoy capsized. Last file on the receiver closed and data down loaded.
325	The buoy was reassembled and prepared for deployment, including the repaired Meteosat module.
326	Buoy re deployed from RMAS Warden at 14:25.hrs shore station receiver re initialised.
338	Last data from VHF transmitter.
343	Last data from Meteosat and ARGOS transmitters.
354	Buoy reported ashore.
355	Buoy recovered from beach and transported to Pembroke Dock. The buoy's subsystem modules were returned to IOSDL and the data retrieved.
025	Buoy returned to IOSDL by lorry on its pallet. shore station decommissioned.

Table 4.1.1 Operational Summary for Sonic Buoy during the SWALES experiment.

MultiMet EPROM Logger Data

The MultiMet EPROM Logger records the mean meteorological data. The data from the Young AQ speed, the air temperature and SST sensors were frequency signals which were counted over a 50 second period and the mean values recorded once per minute on solid state memory. The Young AQ direction and the compass data were sampled at 1Hz and 50 second mean values will be recorded each minute. The wind direction data was averaged in the standard way (sum /

no.) so 0 to 360 changes will give a wrong value. The Young AQ's were therefore mounted so that north faced aft (to the back of the buoy). This would mean that in most conditions the averaged data would be of some use. The digital compass data were properly averaged taking any 0 to 360 changes into account. The message format of the logged data was the same as normal 30 channel MultiMet data (Birch et al., 1993)).

Before both deployments the EPROM logger was completely erased to give the maximum storage capacity. After the first deployment the EPROM logger was powered up in the lab to check the directory setup and to down load the data. It was at this point that a failure in the wiring was detected. The fault caused the main power supply to the EPROM logger to be missing, therefore there were no data stored. The fault was corrected and the EPROM logger was prepared for the second deployment. Unfortunately the same fault re-occurred during the second deployment and again no data were recorded. As a result of these failures the mean meteorological data must be recovered from the backup data in the Formatter Flash EEPROM. These data are 10 minute mean values constructed from the one minute MultiMet values, rather than the one minute samples of 50 second mean data normally recorded by MultiMet.

Buoy Motion Package Flash EEPROM Data

Data from the Buoy Motion Package was conditionally sampled depending on the wind speed as measured by the second R.M. Young AQ wind monitor. The PCMCIA FlashCard was erased prior to each deployment to give maximum storage capacity. It was dumped to a 4 Mbyte PC file after each deployment, using the ThinCard Reader. The resulting PC file was then split into 4 x 1 Mbyte files for easier handling; these have been transferred to Floppy Disks (2 copies of each) and Magneto Optical Disk. The "Black Box" data for the capsize during the 1st deployment have been separated from these (ASCII file BBDUMP.DOC); other data have not been processed. The files available from the first deployment are listed in Table 4.1.2.

Day Number	Time of Start of Record	Wind Speed Bin	Day Number	Time of Start of Record	Wind Speed Bin
286	1500	1	294	1500	2
286	1800	1	294	1800	2
286	2100	1	306	1200	3
287	0000	1	306	1500	3
293	1500	2	306	1800	3
293	1800	2	306	2100	3
293	2100	2	307	0000	3
294	0000	2	307	0300	3
294	0300	2	313	0900	3
294	0600	2	313	1200	3
294	0900	2	313	1402	Black Box
294	1200	2			

Table 4.1.2 Times of Buoy Motion Package data samples. The ranges of the wind speed bins were: Bin 1 (0 - 5 m/s), 2 (5 - 10 m/s), 3 (10 - 15 m/s), 4 (15 - 20 m/s), 5 (20 - 100 m/s).

During the second deployment the BMP clock appears to have been incorrectly initialised and, as a result, timings of records will be difficult to recover. However, there appear to be 4 x Bin 1 records, 10 x Bin 2 records, 13 x Bin 3 records, possibly 1 or more Bin 5 records and, possibly, a Black Box record. This will require more investigation to sort out.

Formatter Flash EEPROM Data

The Formatter Flash EEPROM logger recorded the data messages which were transmitted by ARGOS and Meteosat satellite links. This was to be a backup system but the failure of the MultiMet EPROM logger means that, for SWALES, the Formatter data is the primary source of mean meteorological values. Each data value was averaged from the 10 MultiMet mean values (each based on a 50 second sampling period) corresponding to the 10 minute period during which the sonic anemometer data were sampled to form a spectrum. Averaging of wind directions took no account of 0° to 360° switches (these were minimised by the anemometer orientation). Averaging of buoy direction was meant to allow for this problem, however this was not properly implemented in the software.

The PCMCIA FlashCard was erased prior to the first deployment; it was not erased prior to the second deployment as there was plenty of space left. It was dumped to a 4 Mbyte PC file after each deployment, using the ThinCard Reader. The resulting PC file was then split into 4 x 1 Mbyte files for easier handling; these have been transferred to Floppy Disks (2 copies of each) and Magneto Optical Disk. The data consist of the (binary) ARGOS database and the (ASCII) Meteosat database, nominally at quarter-hour intervals (5, 20, 35 and 50 minutes past the Formatter hour).

Due to a problem with the Sonic Processor Clock, time jumps occurred during the second deployment, and the data time stamps have had to be corrected, depending upon whether they arise from the Sonic clock or the Formatter clock. The meteorological data for both deployments have now been extracted, corrected and archived.

The data for the first deployment cover the period 1330Z/286 1345Z/316. The data for the second deployment cover the period 1030Z/325 to 1805Z/338, at which point the Formatter clock reset to zero date/time (by this time the data sources had failed in any case).

GCAT Raw Sonic data on Flash EEPROM

In case of problems in interpreting the wind spectra calculated by the Sonic Buoy processor, it was considered desirable to record the raw (21Hz) data from the Sonic anemometer. The primary source of these data for SWALES was the RF link to the shore station. However since that was an untried system, samples of raw Sonic data were recorded on Flash EEPROM. The data were stored on a regular time sampling basis (10 minutes every 2 days, starting at midday on the 2nd day after power-up).

The PCMCIA FlashCard was erased prior to each deployment to give maximum storage capacity. It was dumped to a 4 Mbyte PC file after each deployment, using the ThinCard Reader. The resulting PC file was then split into 4 x 1 Mbyte files for easier handling; these have been transferred to Floppy Disks (2 copies of each) and Magneto Optical Disk. The raw data files will require to be split up from these files (a relatively trivial operation as they are already in FASTCOM format), before they can be re-processed if required. The files available are listed in Table 4.1.3.

VHF Sonic Raw Data

The raw 21Hz Sonic anemometer data from the sonic buoy were transmitted by VHF link to the Shore Station at Hill Farm, Manorbier. The data were logged by the shore station system to a 450 Mbyte hard disk. The Shore Station was regularly visited and data were down loaded via tape streamer from the hard disk. This was done for data security and to free up space on the hard disk as some of the early data had to be deleted. The total amount of data collected was 540 Mbytes in 5715 files.

First Deployment				Second Deployment	
Day	Time	Day	Time	Day	Time
288	1210	302	1213	330	1216
290	1210	304	1214	332	1216
292	1211	306	1215	334	1217
294	1211	308	1215	336	1217
296	1212	310	1216	338	1218
298	1212	312	1216		
300	1213				

Table 4.1.3 Times of raw Sonic anemometer data samples. The time shown is the end of the recorded data period as given by the Formatter clock.

The raw sonic data arrived at the shore station in one of two modes, prompted or unprompted. The software developed by THORCOM Ltd was able to distinguish between the two types and produced a separate file for each. The prompted data were generated when the Sonic Processor was taking a 10 minute record from the sonic anemometer, whereas the unprompted data were generated when the sonic anemometer was left in free run mode during the 5 minutes while the sonic processor waited for the next data collection cycle start. During the first deployment the data started at 1430Z/294 and ended at 1402Z/313 when the buoy capsized. For the second deployment the data started at 0924Z/327 and ended at 2109Z/338 due to the failure of the buoy batteries.

ARGOS Data

During the deployments, data were received from the Sonic Buoy via the ARGOS system, which was regularly interrogated during the experiment to allow checks on both buoy position and data quality. The ARGOS messages, downloaded from the CLS ARGOS computer at Toulouse via the Public Switched System were decoded and sorted by the Quick Basic applications ARGSONFILE and SORT RECS. The former decoded all Sonic ARGOS messages within an ARGOS dump into parameters; the latter sorted the parameters into chronological order, selecting the best choice from duplicated data, and calculated preliminary wind stress and drag coefficient values. Plots of the preliminary data were used to ensure that the buoy systems were functioning correctly. ARGOS data were received continuously until the buoy's batteries were depleted.

For the 1st deployment ARGOS data started at 1430Z/293 and terminated when the buoy capsized, the last data transmitted were at 1315Z/313. For the 2nd deployment ARGOS data started at 1430Z/326 and ended at 0445/338, although the last positional data received over ARGOS was at 2145/343.

Meteosat Data

Both for data security and for monitoring the progress of the buoy during SWALES, data were transmitted by the Meteosat system. This data is first received by Darmstadt and then retransmitted via Meteosat to be received by the IOSDL message recovery unit. The IOSDL receiving station was controlled by a Macintosh running an application which automatically decoded and filed each message. The files have been checked, sorted and converted into tabular form.

Just prior to the first deployment, when fresh batteries were installed in the buoy, the Meteosats battery charger for the secondary cells failed. With the buoy about to be deployed there was little time to effect a repair and the Meteosat transmitter was removed from the buoy, giving no data during the 1st deployment. Prior to the second deployment the fault was diagnosed and the charger repaired, enabling Meteosat operation. The failure had been caused by installing fresh batteries while the secondary cells were flat.

Data is available for the second deployment over the period from 1000Z/326 to 1200Z/338 (last good data as buoy subsystems were failing). The last Meteosat message was at 0300Z/343.

4.1.4 Data Products

The data from the Sonic Buoy systems are discussed in a series of Internal Documents (Birch et al., 1994a; Clayson, 1994b; Clayson and Pascal, 1994); the data resulting products are summarised in Tables 4.1.4 and 4.1.5.

Raw Data Files

Source	File name	Description
Sonic Processor: raw EPROM logger data	SONIC2.TXT SON325.TXT	1315Z/285 to 1345Z/313 (10.073446 Mb) 1330Z/325 to 2015Z/338 (4.808961 Mb)
Formatter data: raw PCMCIA Flash Card data (binary files)	FORMSWAL.1MG FORMSWAL.2MG FORMSWAL.3MG	Directory and 1st deployment to day 306.25 Remainder of 1st deployment and most of 2nd End of 2nd deployment (not useful due to low batteries)
GCAT Raw Sonic data: raw PCMCIA Flash Card data	RAWSWAL.1MG RAWSWAL.2MG RAWSWAL.3MG	(binary files)
BMP data: raw PCMCIA Flash Card data	BMPSWAL.1MG BMPSWAL.2MG BMPSWAL.3MG BMPSWAL.4MG	First deployment (binary files)
	BMPSWAL2.1MG BMPSWAL2.2MG BMPSWAL2.3MG BMPSWAL2.4MG	Second deployment (binary files)

Table 4.1.4 List of raw data files from the Sonic Buoy internal logging systems.

Processed Files

Source	File name	Description
Sonic Spectral data: The decoded EPROM logger data in ASCII files	SONIC2.DOC SON325.DOC	1315Z/285 to 1345Z/313 (4.959234 Mbytes) 1330Z/325 to 2015Z/338 (2.367488 Mbytes)
BMP data	BBDUMP.DOC	A section of "Black Box" data during the capsize, in tabulated format.

Table 4.1.5 List of processed data files from the Sonic Buoy internal logging systems.

4.1.5 Comments on Buoy performance

The first deployment was ended with the buoy capsize. This was disappointing since the wind speed at the time was significantly less than had been encountered during the buoy trials (Appendix B). Data from the buoy motion package (Figure 4.4) shows that the buoy capsized backwards. Prior to capsize the x and y accelerations were small and the z acceleration shows the effect of the waves on the apparent gravitational acceleration. At capsize the x acceleration shows that buoy tilted forwards and then rapidly backwards (positive x). The buoy then rotated starboard side downwards continuing to slowly turn completely over. Although the buoy turned onto its side in about 2 seconds, the whole capsize lasted several seconds. Based on this information, the mooring was redesigned and during the second deployment the buoy successfully survived the extreme storm on day 342 remaining upright and on station until the secondary batteries for the ARGOS transmitter failed on day 343. Unfortunately the new mooring design tended to make the buoy align more with the current, rather than the wind (Figure 4.5) and more data editing will be required to choose periods when the sonic anemometer was correctly aligned with the wind.

The useful part of the second deployment was ended by the primary batteries becoming exhausted. As a result, no information is available to determine how the buoy came adrift sometime between days 343 and 350. The battery performance was somewhat less than expected. Based on using the full capacity of the battery packs as specified by the manufacturer, the expected battery duration was as shown in table 4.1.6. However it was not known how close to this would be achieved. The original experiment specification was for a deployment of 6 to 8 weeks (42 to 64 days) with a full buoy array operating for at least four weeks. Given the estimates in Table 4.1.6 it was decided to use all the systems in the buoy. In the event a total battery duration of about 37 days was achieved with 32 days good data. Since the other buoys operated properly during the same period, and a good mix of weather occurred, this disappointing battery life did not prevent a very successful experiment field phase.

Buoy configuration	No. of packs	Duration
All systems: Formatter/sonic processors; MultiMet; Argos/Meteosat transmitters; Buoy raw data system; HF raw data system; Buoy motion package (BMP)	5	61
No BMP	6	72
No BMP, no HF raw data system	6	81
No BMP, no HF raw data system, no buoy raw data system	6	88
No HF raw data system, no buoy raw data system	5	72

Table 4.1.6 Predicted battery duration (days) for different buoy configurations. Exclusion of the Buoy Motion Package (BMP) allows the use of an additional battery pack.

Both the air and sea temperatures were measured on the Sonic Buoy by two sensors. Figure 4.6 shows histograms of the differences between the two air temperature measurements for each phase of the deployment. Sensor (Ta1) read between 0.2°C to 0.3°C higher than sensor (Ta2). Examination of the recorded temperatures after the buoy capsize (when the air temperature sensors recorded the sea temperature) suggests that sensor (Ta2) was correct. Histograms of the sea temperature differences are shown in Figure 4.7. On the first deployment sensor (SST1) read 0.1°C higher, and on the second deployment 0.2°C lower, compared to sensor (SST2). Consideration of the data at capsize, and comparison with the Waverider sea temperature sensor, suggests that the lower sensor was correct; that is SST2 for deployment 1, and SST1 for deployment 2.

4.2 Directional Waverider

4.2.1 Hardware

The buoy used during the SWALES experiment was a standard Datawell Directional Waverider (DWR), equipped with ARGOS transmitter and EEPROM logger. The buoy serial number was 30015 and the ARGOS ID number was 7276. The DWR was used with a standard Datawell mooring (Figure 4.8) The mooring was designed to survive 20 metre maximum wave height with current of 1.6 m/s in 40 m water depth (table 1 in Datawell (1990)).

4.2.2 Operational History

The buoy was prepared at IOSDL and transported to Pembroke on its cradle pallet. The internal logger was initialised in the Pembroke H.M. Moorings and Salvage hangar, the buoy being powered up at 0830Z/288.

The buoy was deployed at 1518Z/293 from the Warden; data are considered to be usable from 293.6667 onwards. On day 300, a fishing boat reported that it had fouled the mooring with its trawling gear. It was forced to cut loose its gear, which was buoyed off, due to worsening weather. On day 303, the situation was assessed from Scarab and it appeared that the fishing gear must have fouled on a sea floor obstruction and not on the DWR mooring. However on day 310 inspection from the Warden suggested that the mooring had by then been fouled. The buoy was re-deployed at 1600Z/310.

The buoy was cut loose on or about day 315, and was subsequently recovered using a range boat on day 316 and transported back to Pembroke Dock. It was re-deployed at 1355Z/326 using the Warden.

The buoy was finally recovered at 2015Z/006 using the Grasmere; it was brought back to the H.M. Moorings establishment, where it was powered down and subsequently transported back to IOSDL.

4.2.3 Data Sources and Processing

For an overall view of the data sources and processing, see Figure 4.9. A full description of the data handling operations, including data products, is given in ref. (Clayson, 1994a), but a summary follows.

ARGOS Data

During the deployments, data were received from the DWR via the ARGOS system, which was regularly interrogated during the experiment to allow checks on both buoy position and data quality. The ARGOS messages, downloaded from the CLS ARGOS computer at Toulouse via the Public Switched System were decoded and sorted by the Quick Basic applications ARGDWRFILE and SORT SPECS. The former decoded all DWR ARGOS messages within an ARGOS dump into directional spectra; the latter sorted the spectra into chronological order, selecting the best choice from duplicated spectra, and produced chronologically ordered tabular files of the parameters Hs, Tz and Temperature in addition to the complete spectral files.

The ARGOS system could not acquire all of the half-hourly data messages produced by the buoy; there were also occasional transmission errors in the messages, which do not incorporate parity checking. The ARGOS data terminated with the recovery of the buoy at 1994Z/006.

Internal EEPROM Logger

The EPROM logger became full on day 364 before the final recovery of the buoy. The complete data set for days 288.4583 - 364.4167 was recovered from the buoy's internal EEPROM logger. The logger contents were dumped to a PC disk file, using the Datawell application LOGGER.BAS. The resulting file was then decoded by the Quick Basic application DWDUMPDEC to a spectral file of the format produced by ARGDWRFILE; SORT SPECS was then run to produce a file of the concise parameters.

4.2.4 Data Products

Data type	Data source	File name	Period
Raw Data File	EEPROM	DWSWAL0.LOG	288.4583 - 364.4167
Processed Spectral File	EEPROM	DWSWAL0.DEC	288.4583 - 364.4167
Processed Parameter File	EEPROM	DWPARS	288.4583 - 364.4167
CricketGraph Data	ARGOS	WRclean.crk.	293.6812 - 006.9037
CricketGraph Data	EEPROM	1st Deploy Params	293.0000 - 316.9792
CricketGraph Data	EEPROM	2nd Deploy Params	326.0000 - 364.4167

4.2.5 Comments on buoy performance

On first inspection the data from the Waverider showed very high Hs values (*ca.* 15m) during the storm of day 342. This would have implied a peak to trough wave height of about 30m which seemed unlikely given the water depth of 40m to 50m. A time series plot of Hs also showed, in addition to a period of high Hs , a few spikes during the following week. Examination of the energy spectra showed that, during the suspect periods, there was a very large peak in the spectrum at a frequency of about 0.025 Hz; this corresponds to the natural period of the stable platform used in the Datawell sensor. Unrealistic values of mean direction and directional spread were also present in these records. This was symptomatic of a disturbance of the buoy's stable platform which normally results from an unusually large rotation or rotational rate of the buoy, e.g. if the buoy is spun when passing along the waterline of a ship, during a recovery operation, or a collision. One might also expect the hull to be subjected to excess rotation in conditions of very high breaking waves, as were present during most of the suspect periods. During the first deployment, there were 2 occasions were bad Hs, Tz values occurred and these were followed in both cases by a record with a bad temperature value and a minor amount of very low frequency energy. One of the instances was during re-laying of the mooring by Warden, the other could have been due to interference by a fishing vessel. The values of Hs, Tz or Temperature for the affected records were deleted from the data files.

Plots of Hs vs. Tz showed that almost all Hs values lay below the $\lambda z/14$ limit calculated from the dispersion relationship without correction for current, i.e.

mean zero-crossing wavelength, $\lambda z = g.Tz^2/2\pi$ where $g = 9.81\ m\ s^{-2}$

This confirmed that the waves were not exceeding limiting steepness giving confidence in the recorded data.

4.3 VAESAT (Vector Averaging Electromagnetic SATellite buoy)

4.3.1 Sampling Regimes:

The VAESAT Buoy houses a Vector Averaging Electromagnetic Current Meter (VAECM) at 1m depth and a 1 MHz Acoustic Doppler Current Profiler (ADCP) which samples in 16 cells, each 1.4m in depth and hence profiles the current from 2.9m to 24.2m. The VAECM data were recorded internally at 2 minute intervals. In addition the instrument transmitted a 5 record average every half hour via the Argos network. The ADCP data were recorded internally every 10 mins. Data collection (consisting of 100 pings) began on each 10 minute boundary and ended approximately 3 mins later at which point the data were timed stamped.

The VAESAT mooring configuration is shown in Figure 4.10. An InterOcean S4 current meter was suspended at 5m depth beneath the VAESAT buoy. Data were recorded internally for 1 minute every 15 minute interval. In addition a Special Record Block (SRB) was written after every 8 data records.

4.3.2 Data Products

Data were processed using the IOSDL Pstar suite of programs. Table 4.3.1 details the processing carried at various stages from raw ascii data to fully calibrated and corrected data. Further details and plots of the data are available in Crisp et al., (1994).

Instrument & file	Data Processing carried out prior to current file.
ADCP	
swadcp.archAA	Gridded data from raw ascii file
swadcp.archAG	Edit jday to continue beyond 365 (- add 365 to 1994 data)
swadcp.archAP	Correct for compass offset +10° and Magnetic variation of -6°
swadcp.archBD	Remove bad east, north data with Pmdian, spikes greater than 15cm/s.
swadcp.archCN	Linear interpolation of absent east, north data
swadcp.archCZ	Add further 28° compass offset. Calculate relative amplitude data using "adprl2"
VAECM	
swvaecm.archAA	Ascii data to Pstar & calibrate currents * 0.0682314 cm/s
swvaecm.archAF	Create monotonic jday & remove data outside ranges: east: -220 - 450 cm/s, north: -150 - 450 cm/s east rms: 0 - 400 cm/s, north rms 0 - 400 cm/s
swvaecm.archAU	Correct for -38° compass offset & -6° magnetic variation. Further spike removal with Pmdian, spikes greater than 10 cm/s. Interpolate absent data.
swvaecm.archAV	Average data on 15 minute interval

Table 4.3.1 Data processing and products for the VAESAT buoy data.

4.3.3 Comments on buoy performance:

The buoy survived the extremes of weather conditions encountered during the deployment and gave data which were of an extremely high quality except during for a 3 day period, days 364 - 367, when the buoy compass gave erroneous readings deviating very little from north. Since the compass data is shared by both the VAECM and ADCP, the error is apparent in the data from both instruments, (see Figures 5.2 and 5.3 below). The reason for the compass behaviour is not known, although it is known that it will not work properly under extreme inclination. The VAECM gave over 87 days of near perfect data before internal data recording quality degraded, while the ADCP recorded data to it's full capacity, with 10 minute sampling, of 81 days. Both were in considerable excess of the 70 day duration specified for the experiment. The ADCP inevitably suffered some noise on the acoustic signal due to subsurface bubbles under strong wind conditions.

This is the first occasion that we have used the InterOcean S4 but there appears to have been good correlation with the data from the VAESAT and ADCP. Processing was carried out using InterOcean commercial software.

4.4 Mean Meteorological Buoy

4.4.1 Hardware

Buoy description

The Mean Meteorology Buoy (Met Buoy) was developed for the SWALES experiment as a progression from the Toroidal buoy previously employed for deep sea applications. The Met Buoy (based on the VAESAT buoy hull) was proposed as a lighter, smaller and more manageable package with all batteries and logger within one water tight housing. This reduces mast loading and the requirement for several watertight packages. The VAESAT buoy hull is a semi discus hull with a central watertight canister held within the buoys 'bobbin' structure and closed by detachable aluminium bulkheads as deck and hull plates. The buoy mast is constructed to carry meteorological instruments and navigation aids. It needs no standing rigging to support it, giving a reduced windage. The meteorological instruments are at 2.5 metres above sea level.

Sensors and data logging

The Meteorological Sensors and Logger system was based on an Aanderaa package. A Sensor Scanning Unit 3010 was used to interconnect and to provide switching and formatting of the sensors. This unit has a selectable 12 channel configuration with only 9 channels utilised in the SWALES configuration (Table 4.4.1). Power was provided to the Scanning unit by two 9v Leclanche cells paralleled with Schottky diodes to give an operating period in excess of 80 days at 20 minute sampling period. The Vector wind sensor was a cup anemometer with a switched Reed sensor. This was interfaced to the Scanning unit using an Aanderaa pulse counter type 2891 and a simple circuit to divide the counts to numbers acceptable with reference to the sampling period of the scanning unit.

The data were logged at 20 minute intervals to an Aanderaa Data Storage Unit (DSU) type 2990E through 6 core cable from the Scanning unit. The DSU has its own internal settable clock to monitor time of scans at 24 hour periods and on/off times. The unit was powered by an internal Lithium cell with a seven year operating lifetime.

Channel	Sensor	Type
1	Reference value	Fixed value
2	Wind direction	Aanderaa 2750
3	Wind speed average	Aanderaa 2740
4	Wind speed Gust	Aanderaa 2740
5	Buoy Orientation	Aanderaa.
6	Air Temperature	Aanderaa 3145A
7	Wind speed	Vector 2536
8	Wind direction	Aanderaa 2057
9	Sea temperature	Aanderaa

Table 4.4.1 Met Buoy channel allocation for the SWALES experiment.

For SWALES the buoy was fitted with an ARGOS PTT transmitter to provide monitoring of the buoys position. The navigation light was a RYOKUSEI Sea Light modified to fit within a housing for external battery supply. The light was Xenon and flashed once per two seconds.

4.4.2 Met. Buoy Operational Experience during SWALES

The buoy was test assembled at IOSDL and all functions checked. The hull was then sealed for deployment with the tower and all sensors removed for transportation and reassembly in Pembroke. The buoy assembled in this format had not been deployed or recovered and a suitable simple scheme was evolved to lift the unit overboard on RMAS Warden. Lifting strops were provided from the buoy deck which positioned a soft strop up to the lifting hook of the gantry. When the buoy lifted it was off vertical with the mast away from the soft strop. As the buoy entered the water the mast came vertical and the lifting hook released and pulled clear of the instruments. At this point an untended gantry line fouled one cup of the Aanderaa anemometer and broke it off.

The mooring (Figure 4.11) was deployed as a combination current and met. mooring and this induced greater drag and lifting loads during recovery than originally planned. However the buoy was recovered with no sensor damage using a recovery line to the lifting strops and hauling aboard. The buoy was returned to IOSDL with mast and sensors removed, but with the hull seal unbroken. On unsealing, the logger and chassis showed no signs of leakage or movement. This was encouraging as the buoy had been subject to severe weather conditions and a significant road journey. The navigation battery packs were at acceptable working voltages. However the Scanning unit batteries were below operating voltage. The navigation light was working correctly. The ARGOS beacon appears to have failed electronically. The Scanning unit had stopped working prematurely and on testing all parts it was found that the Aanderaa wind sensor had failed and was taking significant continuous current. This had caused the battery failure. The DSU was found to be working correctly and stored data extracted for analysis. The DSU clock was checked to determine time of failure and as a measure of clock drift with reference to events measured. This failure was disappointing as data was not acquired throughout the entire deployment period. This fault has not been observed at IOSDL before and the sensor is to be sent to Aanderaa for assessment.

All other sensors were tested and found to be functioning correctly. The Vector wind sensor bearings were quite noisy and stiction was significantly high.

The mast top ring was damaged and welds broken through. There appears to have been an impact on the ring from beneath. This would indicate that the buoy has been interfered with, perhaps by a passing vessel. The mast otherwise was in good condition. There was no damage to either deck or hull and minimal corrosion on the deck. However the hull plate under the buoy had started to corrode and significant corrosion was apparent on the temperature sensor. This plate and assembly had not received the full protective coatings on assembly due to time constraints. The assembly can be recoated and reused.

4.4.3 Aanderaa current meter mooring

Two Aanderaa current meters were deployed with subsurface buoyancy beneath the Mean Met. Buoy. Data were recorded internally every 15 minutes. During recovery of the mooring the bottom instrument was lost due to failure of the spindle assembly. The upper instrument was recovered with a broken fin assembly and examination of the data revealed this occurred on day 353, when a sudden degradation of speed and directional data was apparent. The data quality was generally good but suffered noise on parts of the temperature and depth channels. The variation of the latter indicates the mooring suffered high loads and extremes of motion during some periods during the deployment. The data quality deteriorated rapidly after 6600 records giving approx 70 days of data.

4.4.4 Data Products

Data were processed using the IOSDL Pstar suite of programs. Table 4.4.2 details the processing carried at various stages from raw ascii data to fully calibrated and corrected data. Further details and plots of the data are available in Crisp et al. (1994).

4.4.5 Comments on buoy performance

The Meteorological buoy package did not perform as well as expected. After only 3 days, the Aanderaa anemometer (which had been damaged during deployment) failed electronically and both wind average and maximum data ceased. Unfortunately the fault also resulted in a continuous drain on the battery pack of 13 mA and these failed after 10 days. A back-up Vector anemometer with a divide by eight counter produced wind speed for this period but the unit reset and recounted on occasions where the wind speed was in excess of 8.2556 m/s. The data for this sensor is represented in it's original form and also after interpolation, the latter however will need comparison with other data to check it's validity.

Instrument & file	Data Processing carried out prior to current file.
AANDERAA	
swaand.archAC	Raw data into Pstar format. Calibrate raw data, remove data before instrument in water
swaand.archAJ	Create monotonic jday and correct for -6° magnetic variation
swaand.archAN	Remove data outside certain ranges: speed: 0 - 100 cm/s, temp: 5 - 17°C, pressure: 0 - 40 dbars
swaand.archAU	Create east & north from speed & dirn, Spike removal on temp using Pmdian with value of 0.3 Celcius. Remove temperature outside range 2 - 13.5°C. Linear interpolation of absent temperature data. Cycles 1189 - 1194 set temperature to absent. Rename pressure to depth.
MET Buoy	
swmet.archAE	Calibrate raw data: wdirn1*0.349 + 1.5 degrees, windave * 0.0746, windmax * 0.0746, buoyorn * 0.3516 degrees, airtemp * 0.04323 + airtemp^2 * 0.000004902 - 7.8 degrees, vector speed * 0.008 m/s, sst * 0.04396 + sst2 * 0.000004720 - 8.6 degrees C.
swmet.archAJ	Create monotonic jday, and copy out data in water.
swmet.archAT	Add buoyorn to wdirn1 and wdirn2, correct for 6° magnetic variation
swmet.archBI	Manually correct vector speed data: add 8.2556 m/s to the following data cycles: 184-230, 260-271, 424-500, 106-205, 391, 502-518, 665-669, 673-675, 676-679, 702-711
swmet.archBU	Add 8.2556 m/s to vector speed, cycles 528-584

Table 4.4.2 Data processing and products from the Mean Met buoy and current meter mooring.

4.5 Ship operations

Table 5.1 lists the ship operations during the SWALES field phase. During the planning of SWALES it was decided that meteorological data should be obtained using ship-based instruments as a comparison for data obtained from the Sonic Buoy. The NERC research vessels were not available, so the RMAS ships at Pembroke Dock were used instead. The RMAS Warden was the largest of these ships and the most suitable for deploying/recovering the moorings. Prior to the start of the experiment the IOS 10 metre mast was fitted in the bows of the Warden. The mast carried a Solent sonic anemometer and a pair of psychrometers. The Solent Sonic raw data, spectra and mean wind speeds were recorded continuously as were the usual one minute mean winds, air temperatures and pressure logged by the MultiMet system. A GPS and compass system was also installed and logged continuously. Sea surface temperature could only be recorded when the Warden was on station, since the new sensor "hosepipe" was just led over the side of the ship into the water. Bucket SSTs were also obtained when on station. All these systems worked well, with the exception of the Solent analogue signal to MultiMet which did not work at any time. This may have been due to the crimping of the cable which occurred when the 10m mast was lowered into place. The problem was not considered serious since the separately recorded digital signal from the anemometer (supplying the "raw" data) was unaffected.

Date	Function	Mooring	Vessel
20/10/93	Deployment + Comparison measurements	Sonic Buoy Waverider VAESAT	Warden
30/11/93	Mooring check	Waverider	Scarab
6/11/93	Redeployment	Waverider	Warden
	Deployment + Comparison measurements	Met Buoy with two current meters	Warden
11/1193	Recovery	Sonic Buoy	Halifax
12/11/93	Recovered buoy adrift	Waverider	Falconet
22/1193	Redeployment + Comparison measurements	Sonic Buoy Waverider Marker buoy	Warden
5/12/93	Recovery attempt aborted due to bad weather Comparison measurements		Warden
17/12/93	2nd Recovery Aborted due to bad weather		
6/1/94	Recovery	Waverider	Grasmere
17/1/94	Recovery	Met Buoy with one current meter VAESAT Mooring debris	Warden

Table 5.1 Ship operations during the SWALES experiment

Ship based met. data was to be gathered in two ways; in "opportunistic" mode and in "dedicated" mode. In the first instance the Experiment Officer at IOS was to be informed when the Warden would be on passage in the vicinity of the mooring array and a decision would be made, on the basis of the weather at the time, to request that the ship go hove-to for a period of one hour or more. This should have provided a relatively cheap method of obtaining small amounts of data. "Dedicated" mode meant that the ship would be chartered on the basis of need (for recovering/deploying mooring), or on the basis of 1 to 5 day weather forecasts, for a period of up to 24 hours. This was a more expensive method of data collection since the ship was chartered by the hour and had to be paid for while on the 2 to 3 hour passage to the site, but it should have been useful for more extensive data collection during interesting weather; the forecasted passage of a front, for example.

In practise this did not work entirely as planned. The Warden rarely passed the array and was therefore not available for opportunistic measurements. Dedicated ship time was rapidly used by the need to recover and re-deploy moorings that broke loose or capsized. Rescue and recovery operations for the Waverider and Sonic Buoy (twice) were carried out quickly and efficiently, avoiding excessive damage to, or even loss of, these moorings. However, the availability of the Warden was less than had been expected, which meant that some of the moorings work was performed by other RMAS ships which were not equipped with our meteorological instruments. Despite the fact that the ship based met. measurement programme suffered due to the large amount of moorings work, a reasonable data set was gathered for winds speeds of up to 10 m/s. Higher wind speeds were not recorded since the Warden proved unable to operate in rough seas.

A discussion of the data collected on the Warden is given by Birch et al. (1994b).

4.6 ARGOS data monitoring

Data summaries from the Sonic Buoy, the VAESAT and the Directional Waverider were transmitted via ARGOS satellite. This data were accessed twice daily for the duration of the experiment by a science team member at the JRC. These "Scheduled Mooring Position Checks" usually took place between 9 and 10 in the morning and between 1900 and 2100 in the evening, seven days a week. The ARGOS data was accessed over PSS from the JRC or IOSDL Sun systems (using a modem for the evening and weekend/holiday checks) and collected into a Mac file. The Mac files were processed using a set of QuickBasic programs. The first program to be run performed a check on the position of the moorings, and gave warning if a mooring was off position along with information about how far off position the buoy had gone. Spurious warnings were easy to detect because of their short duration. The other QuickBasic programs converted the raw ARGOS data into physical units in CricketGraph format which allowed the data to be plotted and the instrument performance to be checked. After checking the ARGOS data, the team member at the JRC phoned the Duty Officer on the IOSDL cell phone to inform them of the condition of the moorings. If a mooring problem was detected it was the responsibility of the Duty Officer to initiate the required recovery measures.

This system for checking ARGOS generally worked well. The main problem experienced was the erratic functioning of the US Robotics modem, which sometimes caused delays of up to an hour when trying to access the ARGOS data. The reason for this is not known, but the problem did not occur when a Penril modem was used. The two mooring failures which were detected occurred on day 313 when the Sonic Buoy capsized, and day 315 when the Waverider began to drift. In the latter case the Argos positions of the Waverider were monitored and the buoy movements predicted until the buoy could be recovered on day 316 (Figure 4.12)

4.7 Mooring operations

4.7.1 SONIC Buoy.

Initial Deployment.

The buoy was deployed 20th October 1993 by RMAS Warden. The deployment was buoy first with the vessel making headway at 1 to 2 knots. The buoy was lifted into the stern well by gantry using an RFD no load hook. With the hook released the buoy streamed astern and the mooring line hand deployed to the anchor. The vessel then positioned on slow speed to the intended deployment positon, where the anchor was released using a wire toggle. The buoy was observed to move towards the anchor drop position and with the anchor on the sea floor was observed to steady up into the wind. Visual and ARGOS observations were made on the buoy to ensure sensors and mooring were performing correctly.

A visual check was conducted on the buoy on 30th October 1993 from RMAS Scarab. The buoy appeared to be aligned correctly to the wind and was riding a short confused sea.

Recovery of Capsized Buoy

A salvage attempt was mounted using the RMAS Halifax, a fast patrol boat, on the 11th of November. On arrival at the site the buoy was seen to be capsized and streaming with the current exposing the mooring line at the surface. The Halifax was manoeuvred alongside and with some difficulty a line was passed through the bridle assembly, securing the buoy to the boats forward capstan. These boats have poor low speed control and after several attempts at manoeuvring on the buoy mooring to get adequate slack the decision was made to cut away the mooring and tow the buoy capsized in an attempt to right it. The mooring line was very taut in the tidal stream and was cut using a knife on a boat hook. The buoy was then hand hauled astern where a further line was attached at the mooring bridle plate. By manoeuvring slowly ahead and adjusting the position of tow in the bridles the buoy was righted and towed to Tenby for recovery ashore. On inspection of the bridles and severed mooring line, all the recovered components were found to be in good condition.

Second deployment

The refurbished Sonic Buoy was deployed on the 22nd November 1993 using the RMAS Warden. Deployment was before and the buoy was observed moored on site with the navigation light and ARGOS being monitored onboard. The mooring was observed streamed out on the surface with the two surface floats well out of the water.

Buoy recovery from beach

The buoy was washed ashore in the River Tywi estuary. The mooring had become detached at the outboard end of the surface 5m harness but no sign of either the thimbles or shackles was evident, suggesting some kind of interference may have taken place, or alternatively they had become detached during the buoys movement over the rocks.

Recovery of the SONIC mooring.

A 12 hour weather window for recovery occurred on the 17th January 1994. RMAS Warden sailed from Pembroke at 0935Z arriving at the mooring site at 1215Z. During recovery of the VAESAT at slack water, a trawl float from the remains of the Sonic mooring was observed floating on the surface. This was secured and the mooring successfully recovered onboard. All ropes were found to be in good condition but some shackles showed evidence of wear, presumably as a result of the severe gales of the previous month. The complete absence of the two surface buoyancy floats on the surface line suggested that the mooring may have been tampered with, prior to the buoy breaking adrift. Shackle pins on the upper mooring components were considerably worn by mooring motion. The nylon mooring line showed signs of abrasion when inspected at IOSDL. Reduction in line strength was minimal and the abrasion was probably caused on recovery.

4.7.2 VAESAT buoy.

Deployment.

The buoy was deployed 20th October 1993 by RMAS Warden. The deployment was buoy first with the vessel making headway at 1 to 2 knots. The buoy was lifted into the stern well by gantry using an RFD no load hook. With the buoy in the stern well and hanging on the gantry, the S4 was lowered by hand so that it hung clear in the water beneath the buoy. The hook was then released and the buoy streamed astern with the mooring line hand deployed to the buoy ballast. The ballast was slipped down the stern ramp and the polypropylene mooring line allowed to free run until the buoy ballast chain bottomed out. The remaining line was then hand deployed to the anchor. The vessel then positioned on slow speed to the intended deployment positon, where the anchor was released using a wire toggle. The buoy was observed to move towards the anchor drop position and then steady up with the anchor on the sea floor. Visual and ARGOS observations were made on the buoy to ensure sensors and mooring were performing correctly.

Positional Checks

On the 30th October 1993 the buoy was observed to be riding in a short confused sea with the deck awash at times. The buoy was also observed on the 6th November and on the 6th of January 1994.

Recovery operation.

The buoy and mooring were recovered on the 17th of January 1994 from RMAS Warden. The Gemini was launched and a floating recovery line secured to the VAESAT buoy. The buoy was lifted onboard and the gantry manoeuvred to allow the S4 current meter to be lead safely over the stern. The mooring was all recovered safely by 1515GMT. An examination of the mooring showed no damage or wear to the components.

4.7.3. Directional Waverider mooring.

Deployment.

The mooring was deployed from RMAS Warden on the 20th of October 1993. Deployment was buoy first with the buoy being lowered into the water on the after gantry using the RFD No load hook to release. The buoy had a steady line attached to prevent rotation, which can damage the internal sensors. With the buoy in the water the vessel proceeded at slow speed to deploy the mooring to the anchor. The buoy was then towed onto position and the anchor released.

Possible fishing interference and inspection.

A trawler reported fouling the Waverider to Milford Haven coast guard on the 27th of October. The trawler then abandoned his trawl and warps on site as he was unable to recover them. An inspection and possible rescue attempt was prepared from IOSDL and RMAS Scarab proceeded to sea on the 30th of October with a Survey team member and the standby mooring components. The weather conditions prevailing on site did not permit recovery of the buoy and as the buoy was floating apparently normally no recovery attempt was made. The abandoned fishing gear was identified buoyed off some 200 metres from the buoy.

Recovery and redeployment

The Waverider mooring fouled by the trawl was to be inspected and a possible recovery of the trawl made from RMAS Warden on the 6th of November. The standby mooring was taken onboard for possible renewal of the mooring. On arrival on site the Waverider buoy was seen to floating almost awash with the ARGOS antenna occasionally submerging. An unsuccessful attempt was made to recover the abandoned trawl and it was decided to recover the Waverider. The work boat was launched but it was found impossible to grapnel the mooring as the load on the mooring was pulling the bungee almost vertically down. A floating line was passed from the Warden and attached to the buoy. The Warden then steamed slowly away in the hope of lifting the buoy. The buoy towed underwater and as the ship eased speed was seen to pop up and ride high in the water. The mooring had broken, enabling the buoy to be towed to the ship by workboat for craning onboard. The standby mooring was assembled and after checking the buoy was redeployed. The mooring slipped easily away and the buoy was observed securely moored and floating correctly.

Recovery of drifting Waverider.

The survey team staff transferred to RMAS Falconet by 1200Z on the 12th November and set up the GONIO RDF on the flying bridge. To calibrate the system the Falconet made for the mooring site, on passage the Waverider signal was detected but no direction could be obtained as the GONIO RDF had not been zeroed. Falconet positioned one cable away from the VAESAT mooring with the ships head pointing at the buoy. This enabled the RDF to be zeroed to the ARGOS signal from the buoy. By manoeuvring towards the latest positions relayed from JRC by Cell phone the Waverider signal was relocated and using the indicated RDF direction the Waverider was visually relocated. The buoy was man handled to the boats side, with difficulty due to poor slow speed control, and lifted aboard using the workboat crane. The lower rubber bungee was seen to have been severed 2/3 along its length and on close examination severe abrasion was seen, along with flakes of blue paint embedded in the rubber. This was probably caused by the mooring being caught up on a trawl wire and then bumped along the vessels side in an effort to free the mooring. The cut end appeared severed by a sharp edge, possibly a knife. The buoy was taken to Pembroke on the Falconet and transferred to under cover storage for examination.

Redeployment.

The buoy was redeployed from the RMAS Warden using mooring spares from IOSDL on the 22nd of November 1993.

Final Recovery.

Bad weather prevented recovery until 6th January 1994. RMAS Grasmere arrived on site at 1950Z, low water slack, and located the Waverider. The buoy was seen to be floating with two support floats on the surface. During recovery the lower bungee pulled out of its bottom fitting and the lower mooring was lost. The mooring components recovered were in good condition. The lower section was subsequently recovered on the 17th Jan when it was confirmed that the mooring had failed at the joint of the lower bungee.

4.7.4 Current Profile Mooring.

The current profile mooring was prepared at sea onboard RMAS Warden on 20th October 1994. The Aanderaa RCMs were fully set up and recording correctly. A rig was set up to test the acoustic releases in the water and they were deployed to 20metres depth. The units would not function correctly in the water and were recovered. On deck tests were made using a clip on transducer and neither unit functioned correctly. It was therefore decided to abandon the deployment.

4.7.5 Current Profile and Met buoy mooring.

A mooring design was proposed by the Survey team which incorporated the Met buoy and the current profile mooring as one unit. This mooring required production of new wires and increasing the subsurface buoyancy to cope with the increased surface buoy drag . A design was produced and the mooring assembled in one day from Survey Team stocks.

Deployment.

The revised mooring assembly was assembled at Pembroke on the 6th of November and was deployed that day from RMAS Warden. The buoy was deployed using the after gantry and a short rope strop which could be unhooked when the buoy was afloat in the stern well. This went very smoothly but for damage to one anemometer cup by an untended gantry hook line. The buoy was streamed clear astern and the subsurface slipped down the ramp followed by the mooring wire and current meters. A short tow was required to position and stream out the assembly to prevent tangling. The anchor was then released and the subsurface buoy observed to submerge and the Met buoy to settle on position.

The ARGOS beacon signal appeared correct when deployed but very shortly thereafter became noisy, and spurious values were obtained on the GONIO. As no spare was available the buoy was left on position. Overnight the buoy was monitored and no improvement was seen in the ARGOS quality.

Recovery.

Recovery was delayed to the poor weather conditions until 17th of January 1994 when the Warden was on site again. The Gemini was launched and a floating line attached to the Met buoy. The initial attempt to recover the mooring was abandoned when the Warden failed to maintain station in the strong tidal flow, resulting in the buoy being dragged under. A second attempt was tried with the Warden anchored uptide of the mooring but this was again abandoned. A third attempt proved successful and the buoy was recovered onboard at 1420Z. During recovery, the subsurface sphere appeared on the surface indicating the mooring had failed. Examination showed that the lower current meter spindle had failed at the upper eye end and as a result the current meter and components below it were lost. The upper current meter RCM 7643 had only approx 20cms of the fin remaining and this is can, from the data, be shown to have occurred on the 18th December. Damage to the upper ring of the Met mast may have been sustained at the same time. All other components were in good condition.

5. SUMMARY OF DATA SETS COLLECTED

The periods of good data from each instrument system are shown in Figure 5.1. Because bad weather prevented recovery of the moorings, the field phase of the experiment extended over some 90 days, significantly longer than the 6 to 8 weeks planned. An almost complete set of current data from the VAESAT mooring extends from 29th October (day 293) until the end of the year. Comparison of Figure 5.2, the eastward current component measured by the VAESAT buoy, and Figure 5.3, the northwards component, shows that the tidal current at the site was predominantly east/west. The spring/neaps cycle is clearly evident as also is the 3 day period of compass malfunction starting on day 346.

Wave data is available over a similar period to the current data except for a twelve day break extending from 11th November (day 315), when the Waverider went adrift, to day 326 when it and the refurbished Sonic Buoy were redeployed. Wind stress data are only available when the Sonic Buoy was deployed and working. However using both Sonic Buoy and Mean Met buoy provides mean meteorological data from days 293 to 320 and 326 to 338. Figure 5.4 summarises the mean meteorological data from the Sonic Buoy during the first deployment and Figure 5.5

shows the mean wave data from the Waverider during the same period. The wave period clearly shows the doppler effect of the tidal currents. The short fetch caused by the winds blowing off the land is evident in the limited wave height and period until about day 307.

The wind speed data from the mean met buoy is shown in Figure 5.6. These data extend into the period after day 313 when the Sonic Buoy was not deployed. Also shown is the relative amplitude of the backscatter signal recoded by the ADCP on the VAESAT buoy. High levels of backscatter in the near surface layers correlate with high wind speeds. For the same period the current vectors from the ADCP are shown in Figure 5.7. During the period shown the tides change from neaps to springs. The current estimates are coherent with depth except during periods of high winds. Whether the changes in the current profiles during storms are real or due to the effect of bubble clouds remains to be investigated.

The meteorological data and wave conditions during the second Sonic Buoy deployment are shown in Figures 5.8 and 5.9. Comparison with the previous figures emphasises the rougher conditions during the second deployment. These rough conditions continued until the Waverider was recovered (Figure 5.10). The main disappointment in an otherwise very successful experiment was that no meteorological data were obtained after day 338 due to the failure of both the Sonic Buoy and its backup, the Mean Met. Buoy. However both wave and current data are available and, used with the meteorological data from shore stations, these will provide a valuable further period of data for development of the wave-tide-surge model.

The unique feature of the SWALES experiment was the long time series of wind stress estimates obtained using the inertial dissipation technique and the Solent Sonic anemometer on the Sonic Buoy. These are summarised in Figure 5.11 which shows values of the friction velocity (a measure of wind stress) plotted against the wind speed for each of the deployments. In these preliminary data obtained over the ARGOS link, the wind speed has not been corrected for the effect of tidal currents. Even so, compared to data from previous experiments the Sonic Buoy data exhibit very little scatter. The data appear to follow, but are somewhat lower than, the Smith (1980) relationship. This is unexpected since likely errors in the Sonic Buoy measurements would tend to result in higher, rather than lower, stress estimates; however proper analysis will be necessary to confirm this conclusion. Plotted in Figure 5.12 are the equivalent data from the RMAS Warden. These data show the large scatter typical of previous experiments and appear to be higher than the Sonic Buoy data. Checking and explaining these differences will be an important part of the analysis of the SWALES results.

6. ACKNOWLEDGEMENTS

The SWALES experiment was a complex logistical operation with a duration of five months. It is therefore appropriate that the acknowledgements should start to by mentioning the team of people who worked preparing, deploying and maintaining the complex systems used within the buoys, on board the Warden and at the shore station. Also the resolution of staff who kept 'watch' on the moored systems twice a day, seven days a week, including over the Christmas period. The response of the individuals within the team to meet the operational variability on a day by day basis was the key to the success of the experiment.

There are also other several individuals, groups of people, and organisations to whom we are very grateful for their help, these are : -

The Morgan family at Hill Farm Manorbier for allowing us access to their farm where the radio shore station was erected.

HM Mooring & Salvage Depot at Pembroke, in particular Mr Morgyn Davies for his co-operation and helpful advice particularly at times of high operational activity. Thanks is also due to the Officers and crew of the all the ships that were used throughout the experiment.

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Our thanks are also extended for the prompt actions of the River Tywi Yacht Club and in particular Mr Ollern. Shaw during the recovery of the Sonic Buoy from the River Tywi estuary.

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7. REFERENCES

Birch, K. G., C. H. Clayson and R. W. Pascal, 1994a: *SWALES Sonic Buoy - Telemetered Data Report.* IOSDL Internal Document (in preparation), IOSDL, Wormley.

Birch, K. G., C. H. Clayson and R. W. Pascal, 1994b: *SWALES Warden Systems Data Report.* IOSDL Internal Document (in preparation), IOSDL, Wormley.

Birch, K. G., E. C. Kent, R. W. Pascal and P. K. Taylor, 1993: *MultiMet Scientific Users Manual.* Internal document 10, James Rennell Centre, Southampton, UK, pp. 47 (+apps. on disk).

Clayson, C. H., 1994a: *SWALES Directional Waverider Data Report.* IOSDL Internal Document (in preparation), IOSDL, Wormley.

Clayson, C. H., 1994b: *SWALES Sonic Buoy - Meteorological Data Report.* IOSDL Internal Document (in preparation), IOSDL, Wormley.

Clayson, C. H. and R. W. Pascal, 1994: *SWALES Sonic Buoy - Sonic Anemometer Spectral and Raw Data Report.* IOSDL Internal Document (in preparation), IOSDL, Wormley.

Crisp, N., K. Goy and I. Waddington, 1994: *SWALES - Current and meteorological measurements in support of a Sonic Buoy deployment.* (unpublished manuscript), IOSDL, Wormley.

Datawell bv 1990: Operation and Service Manual for 'DIRECTIONAL WAVERIDER' with Satellite Transmission from serial no. 30015

Flather, R. A., 1993: *Bristol Channel 'Local' Tide-Surge Model.* , A. Polson, Ed., Flood and Coastal Defence 4, MAFF, London, 2 - 3.

Smith, S. D., 1980: Wind stress and heat flux over the ocean in gale force winds. *J. Phys. Oceanogr.*, 10, 709-726.

8. FIGURES

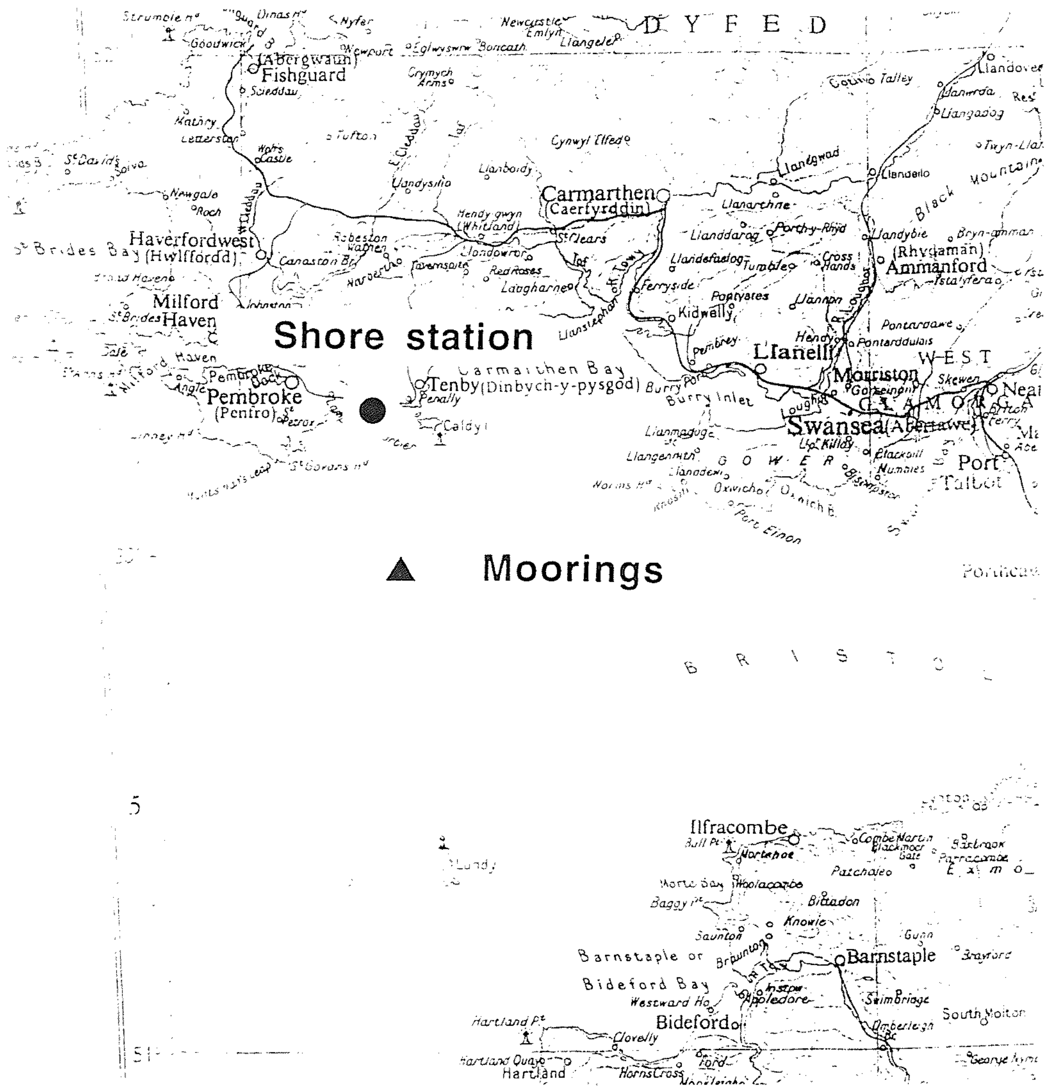


Figure 1.1 Position of the SWALES mooring array.

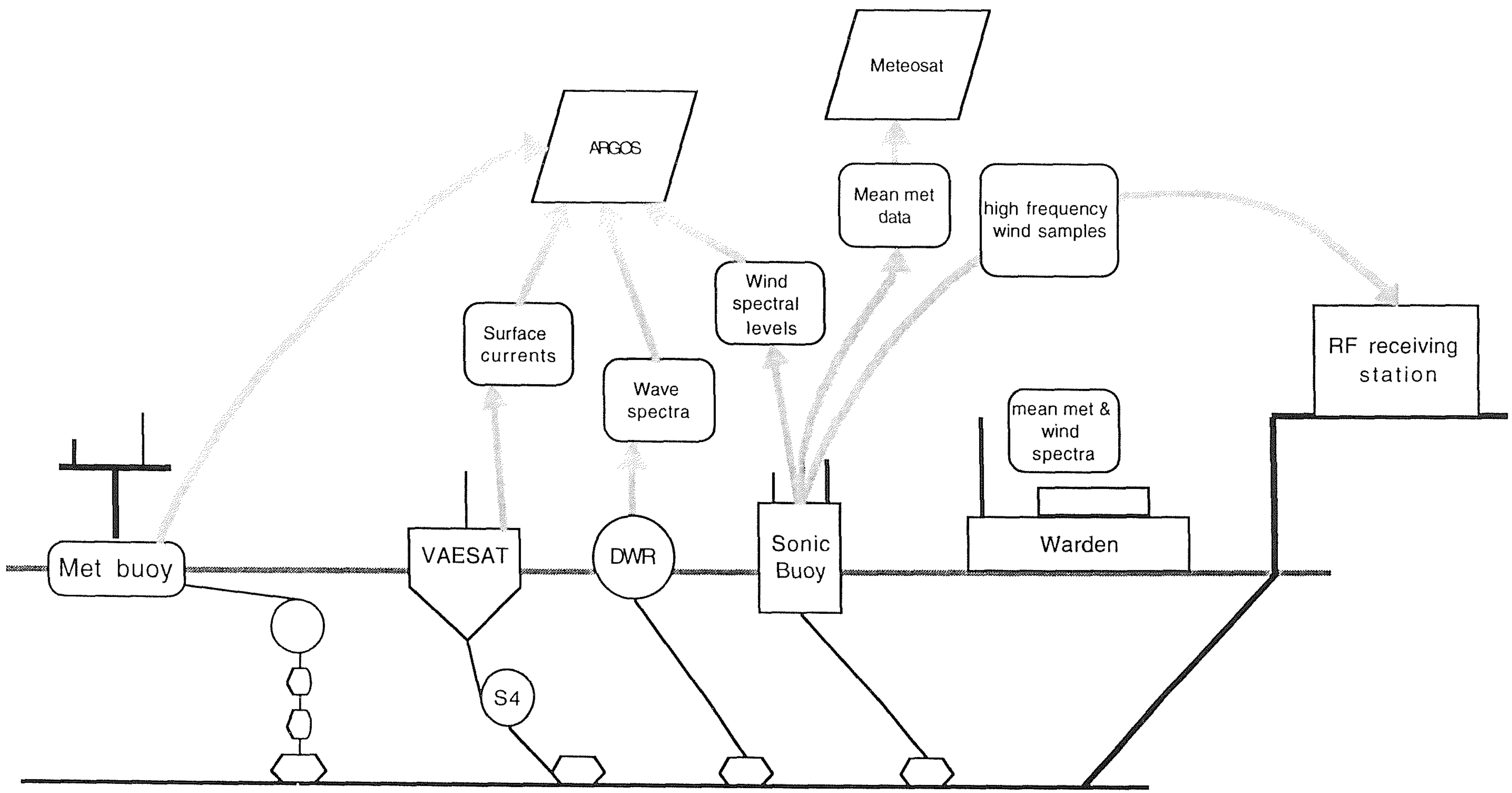


Figure 1.2 Diagramatic representation of the SWALES field Phase components.

DEPTH AT L.A.T. = 40 m

BUOY LENGTH SWING
radius

sonic 160 + 60% 253

VAESAT / 20 vertical + 92
met toroid 100

waverider 120 113

current
+ met ?? ??

ship 50 + 80
mooring 50 (ship)

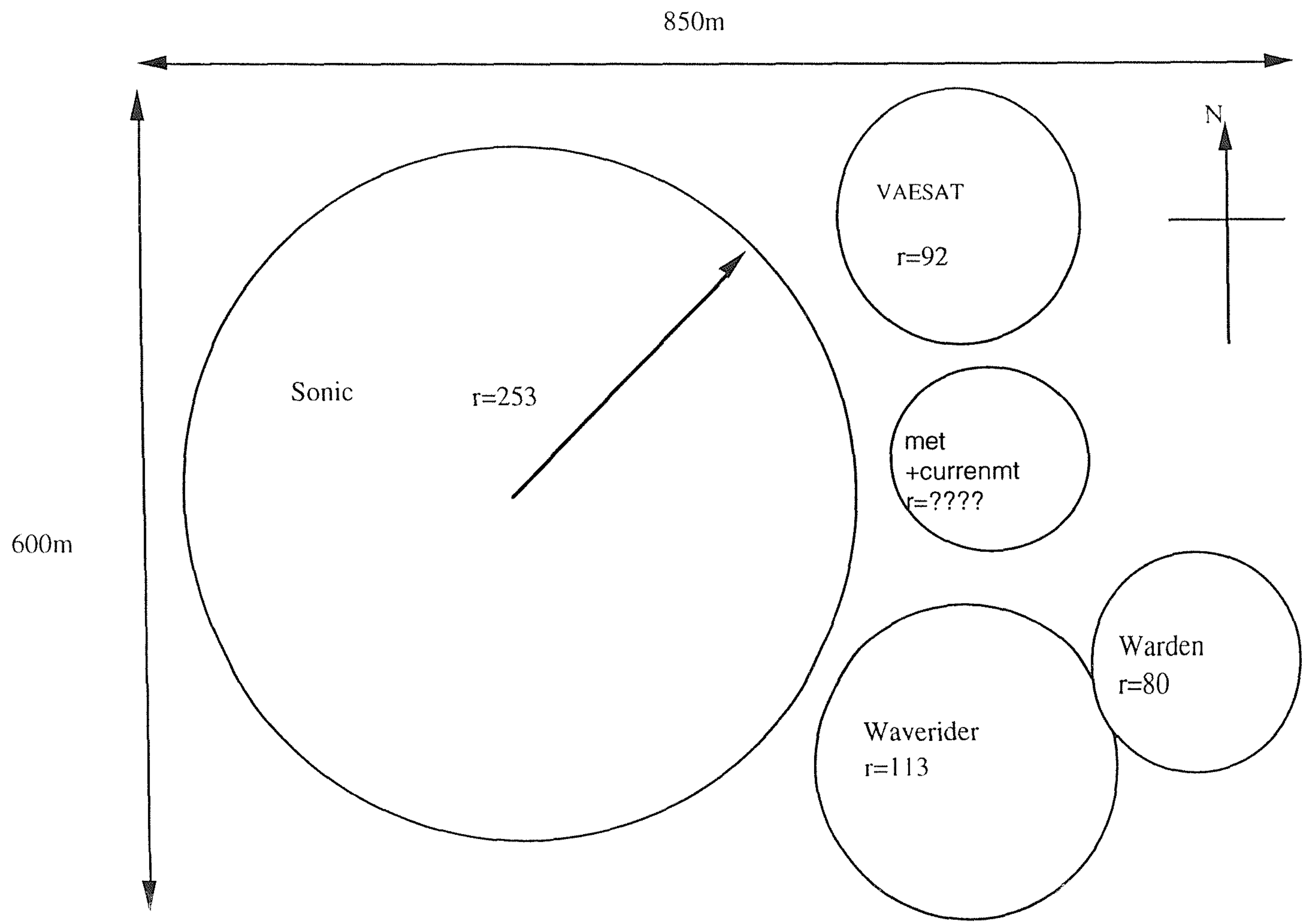


Figure 1.3 Position of moorings within the SWALES mooring array

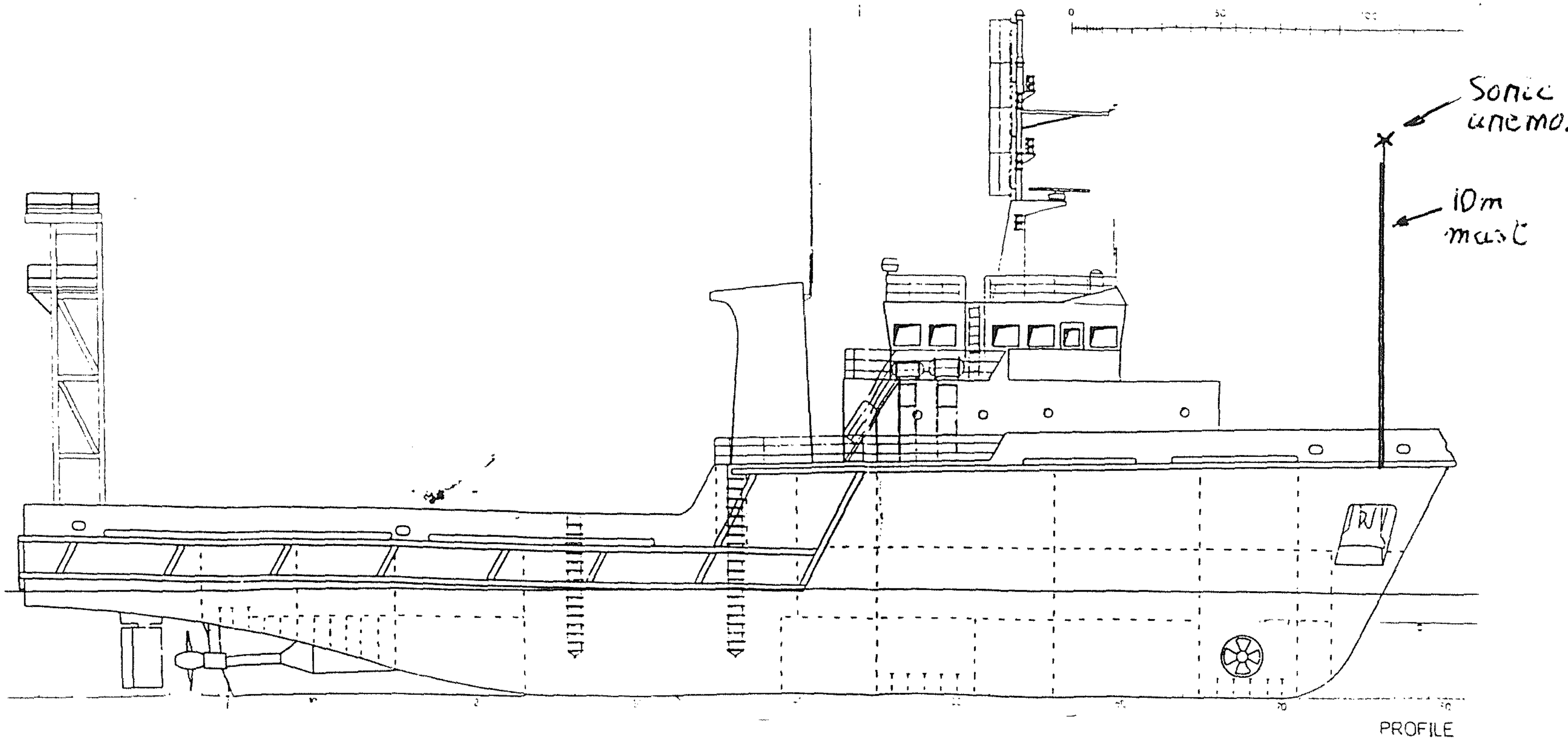


Figure 1.4 The site of IOSDL meteorological instruments on the RMAS Warden.

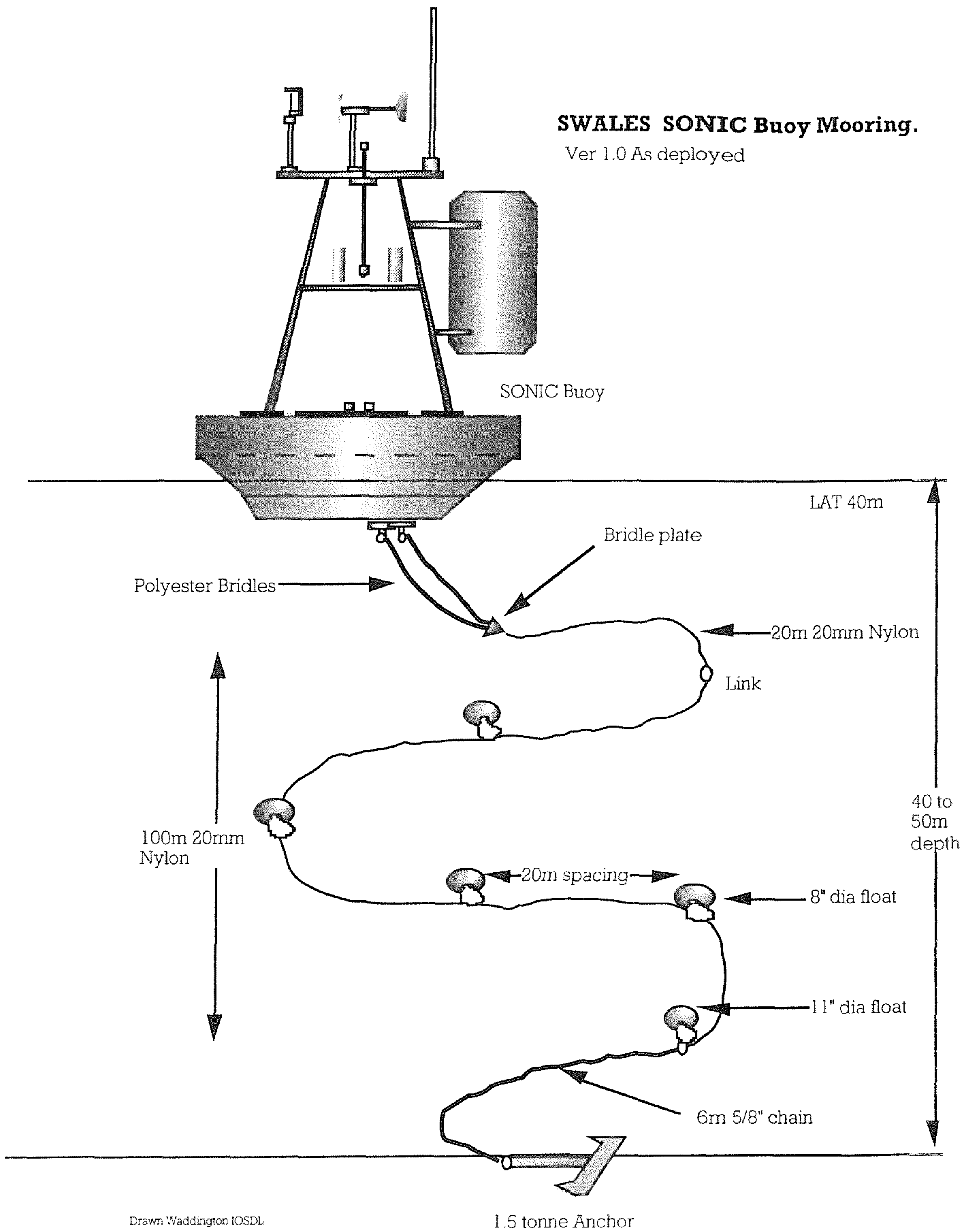


Figure 4.1 The first Sonic Buoy mooring

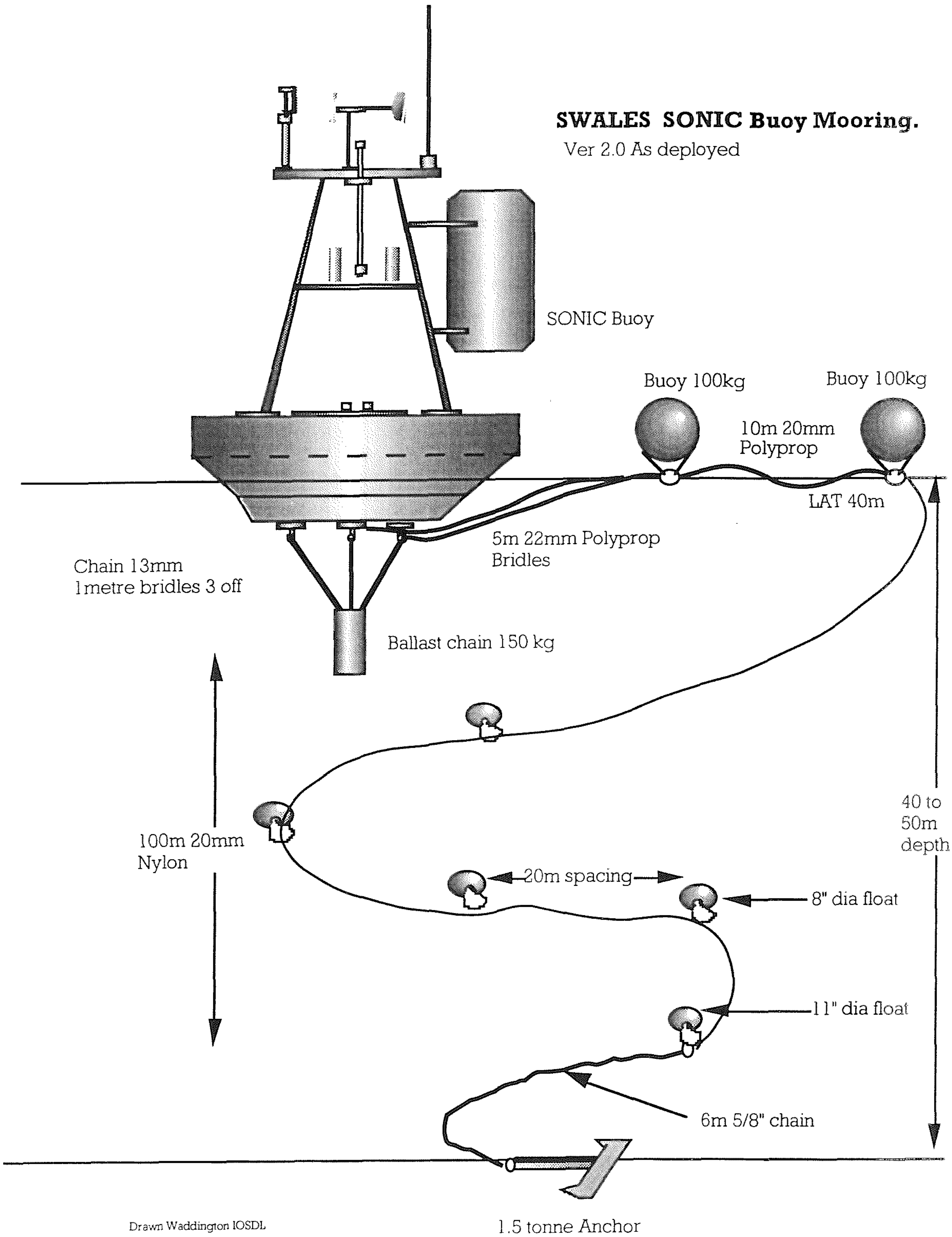


Figure 4.2 The second Sonic Buoy mooring

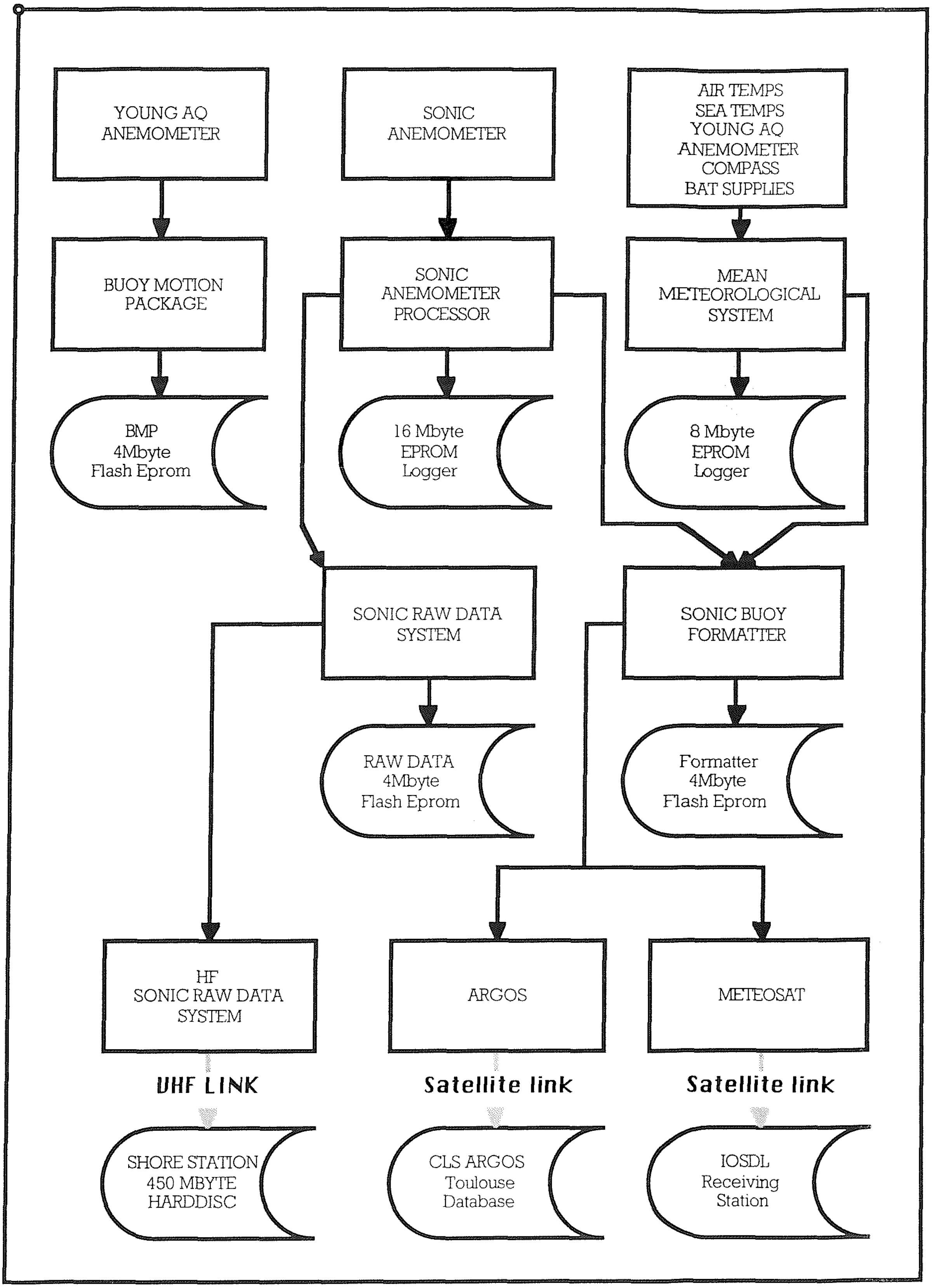


Figure 4.3 Sonic Buoy Data Acquisition

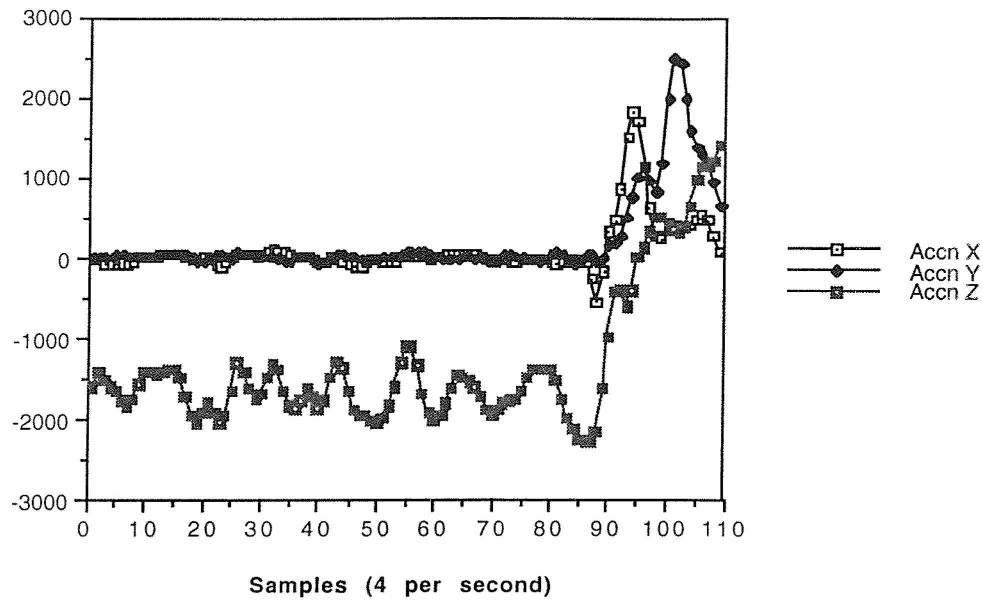
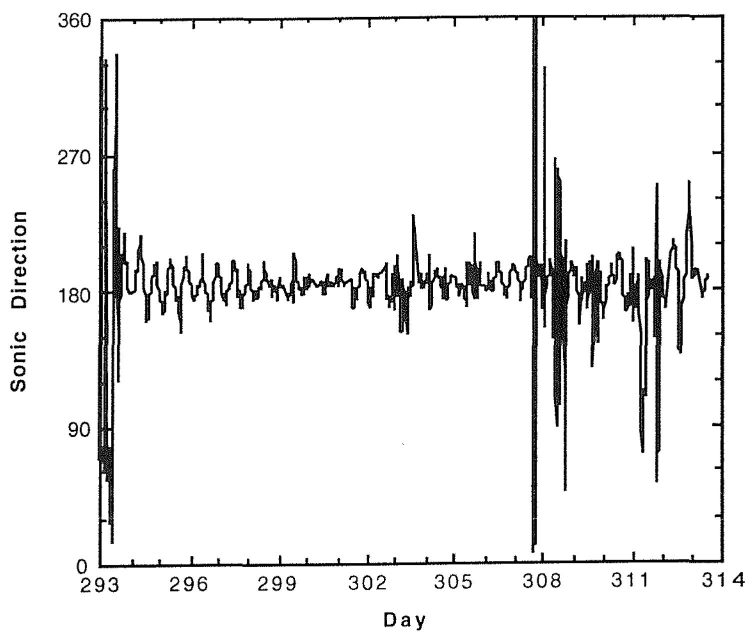


Figure 4.4 Data from the buoy motion package at the time of capsize.



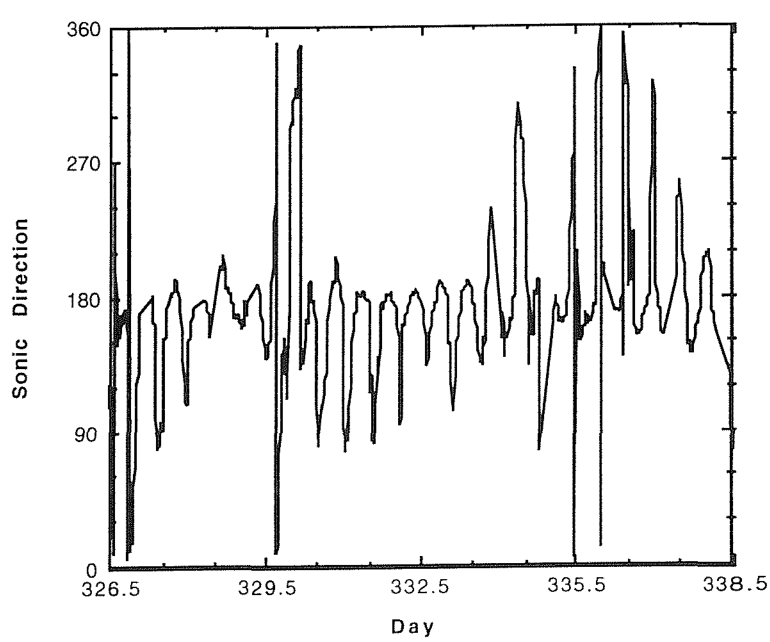


Figure 4.5 **Alignment of the Sonic Buoy relative to the wind. (a) First deployment; (b) Second deployment**

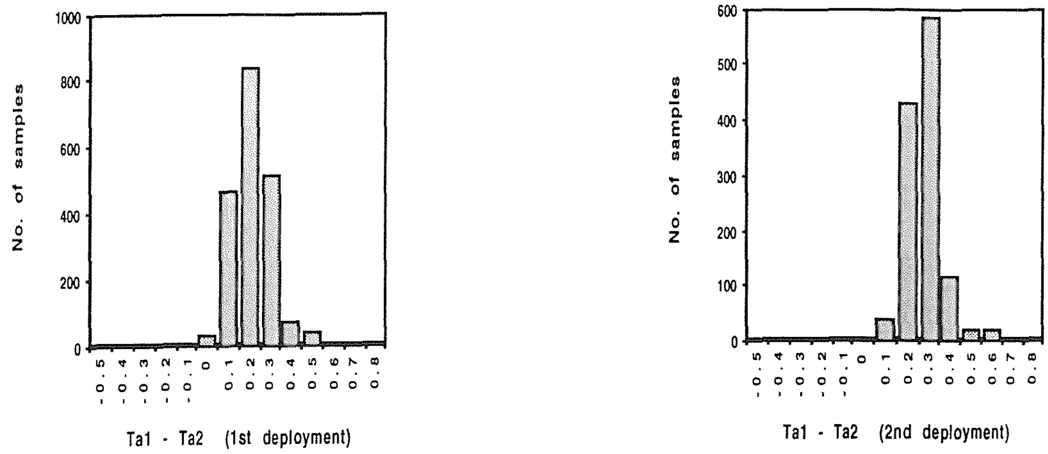


Figure 4.6 Histograms of the differences between the two air temperature measurements on the Sonic Buoy (a) First deployment (b) second deployment

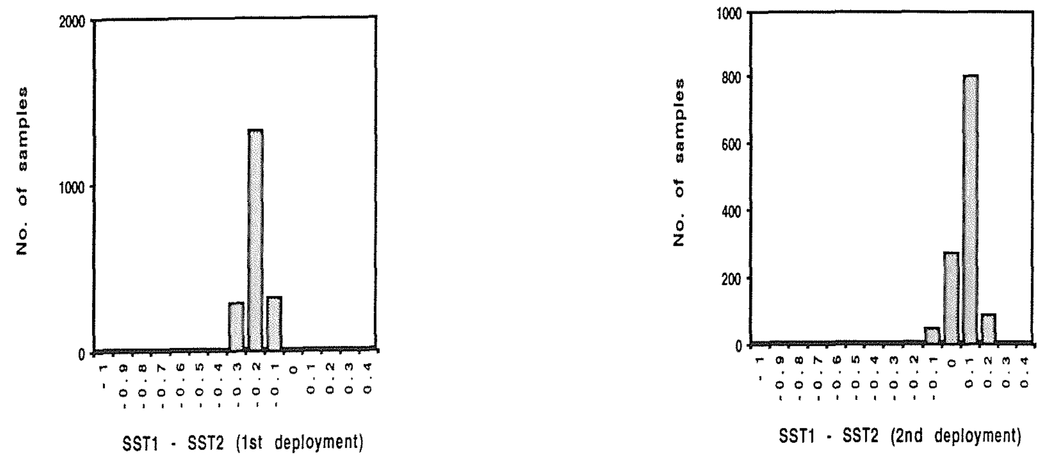


Figure 4.7 Histograms of the differences between the two sea temperature measurements on the Sonic Buoy (a) First deployment (b) second deployment

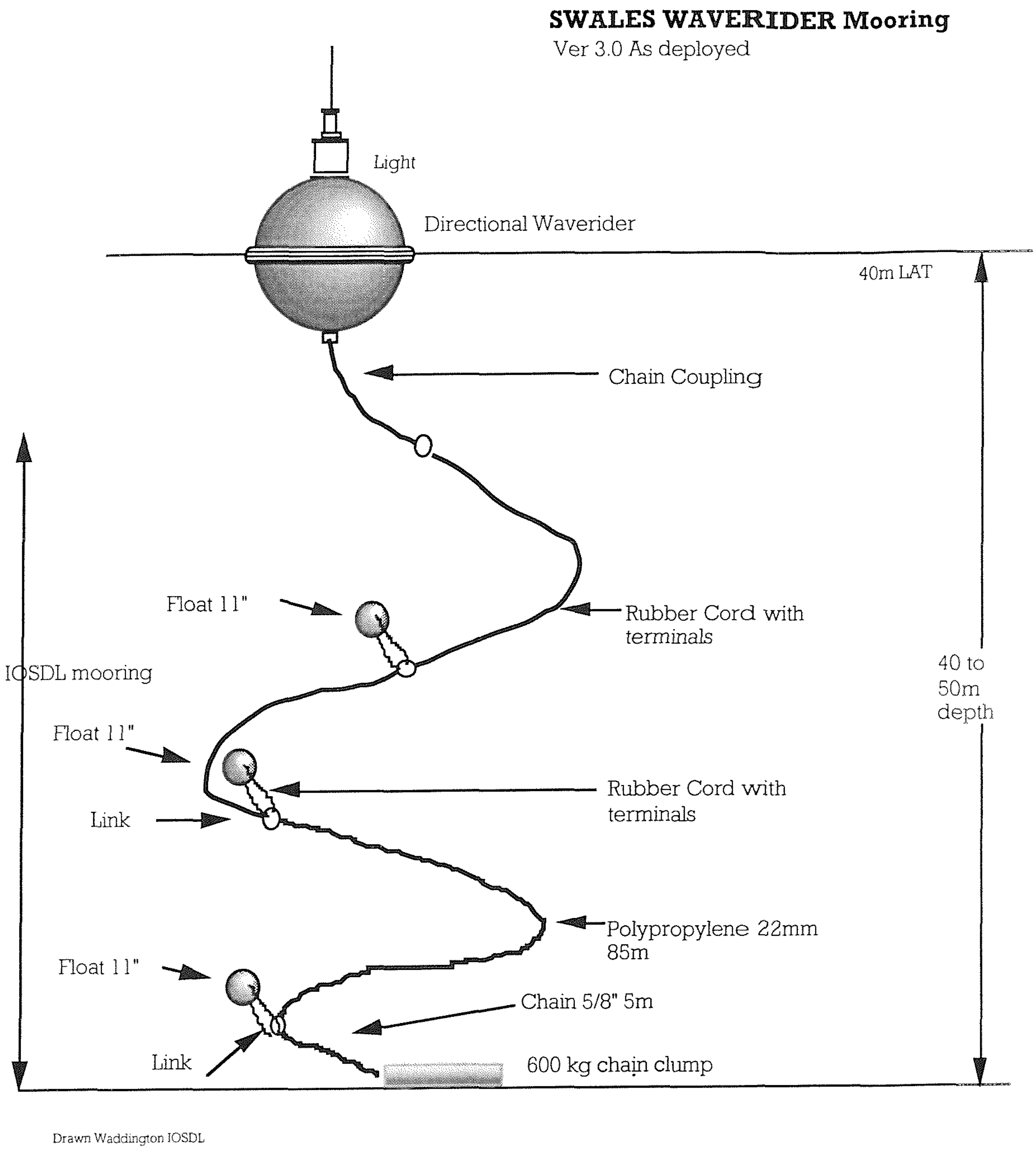


Figure 4.8 The Directional Waverider mooring

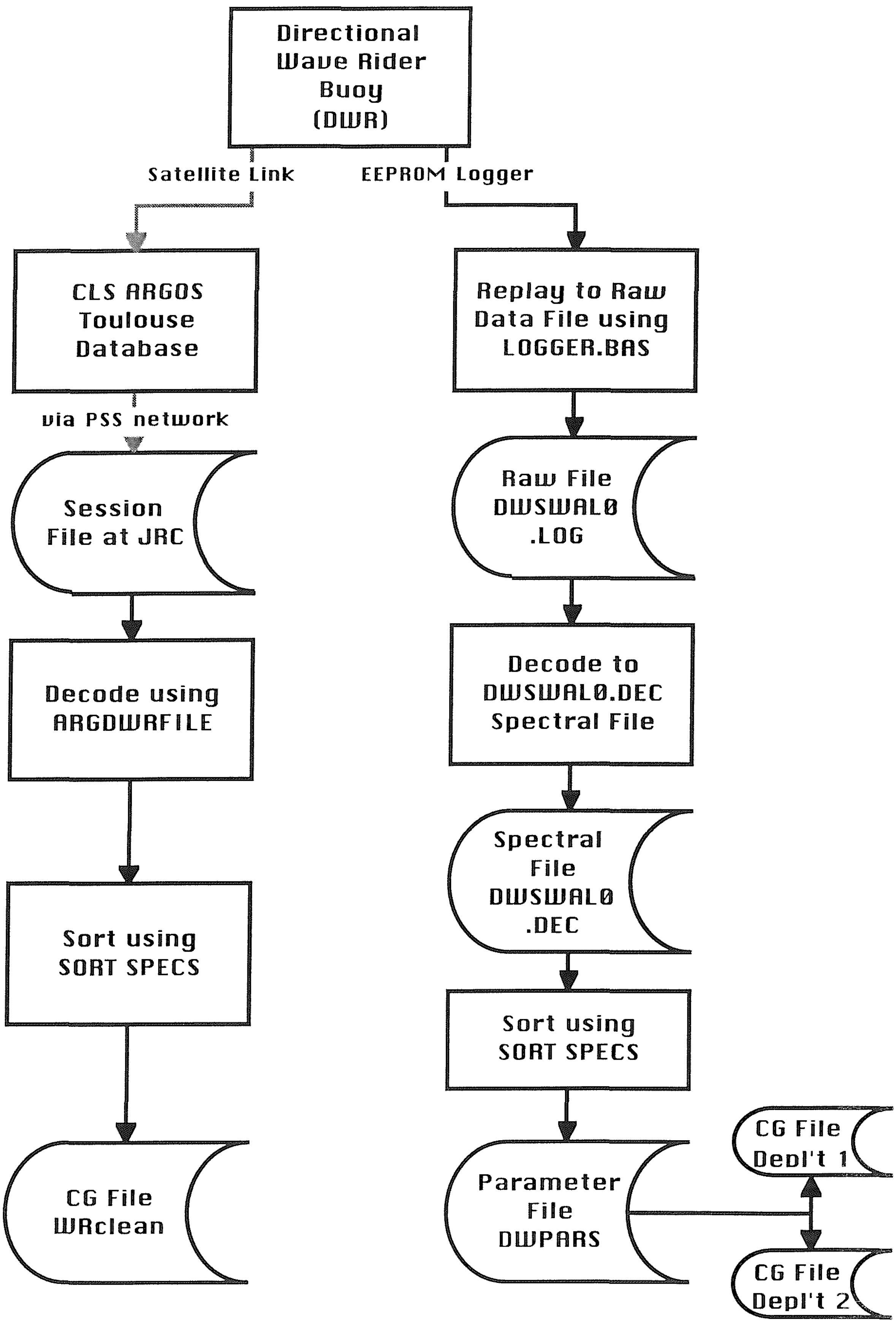


Figure 4.9 Data sources and processing for the Directional Waverider.

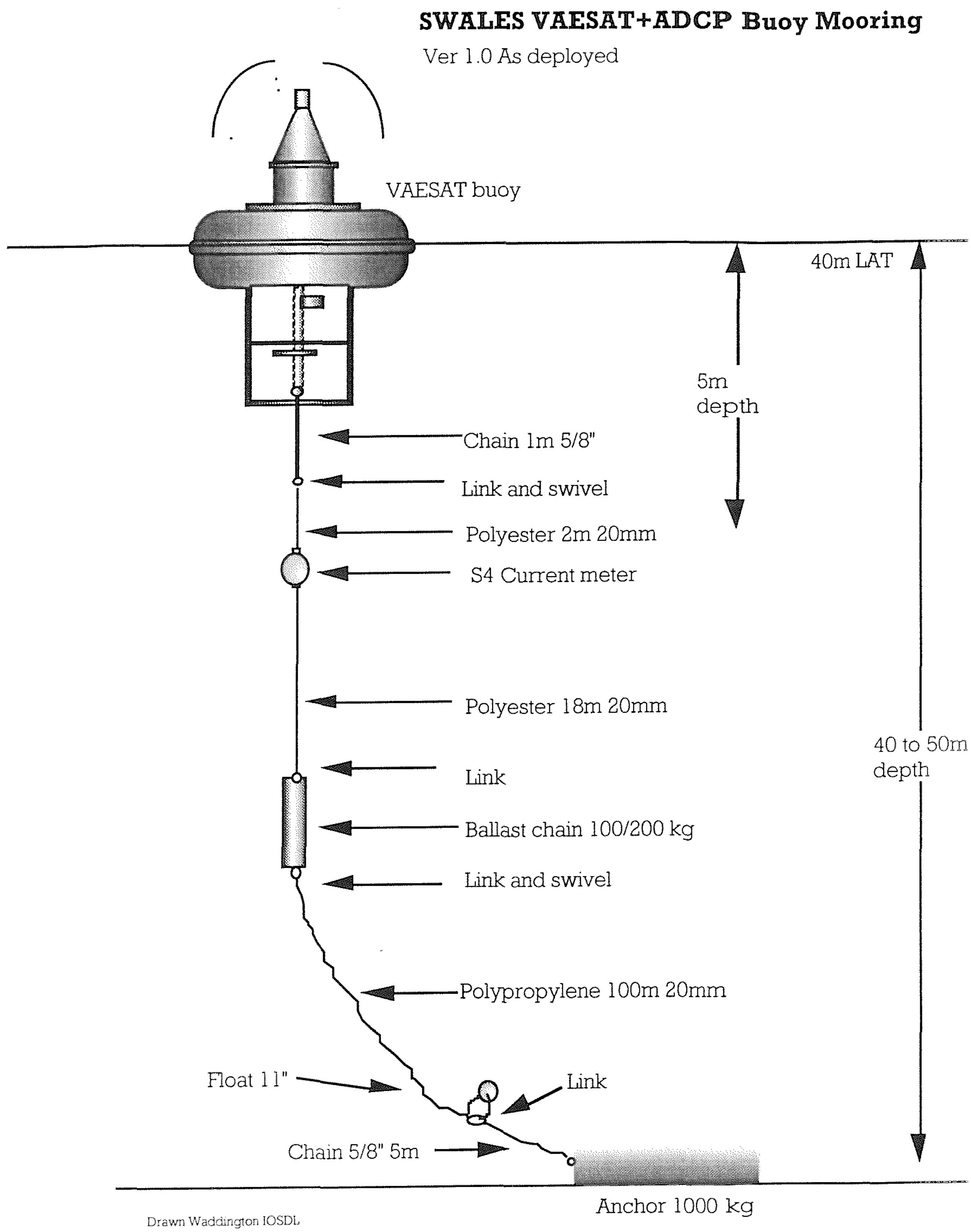


Figure 4.10 The VAESAT mooring

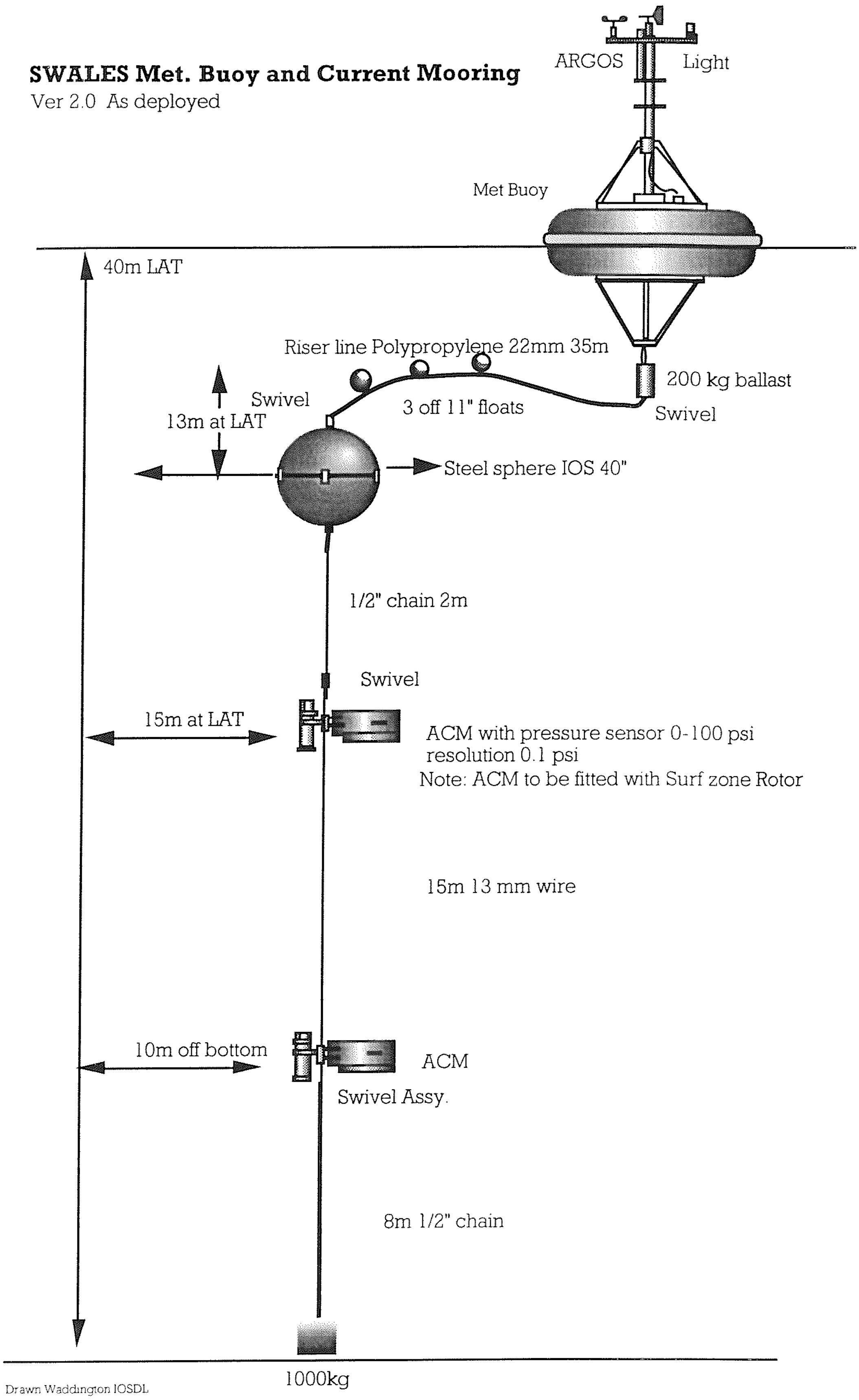


Figure 4.11 The Mean Meteorological Buoy mooring

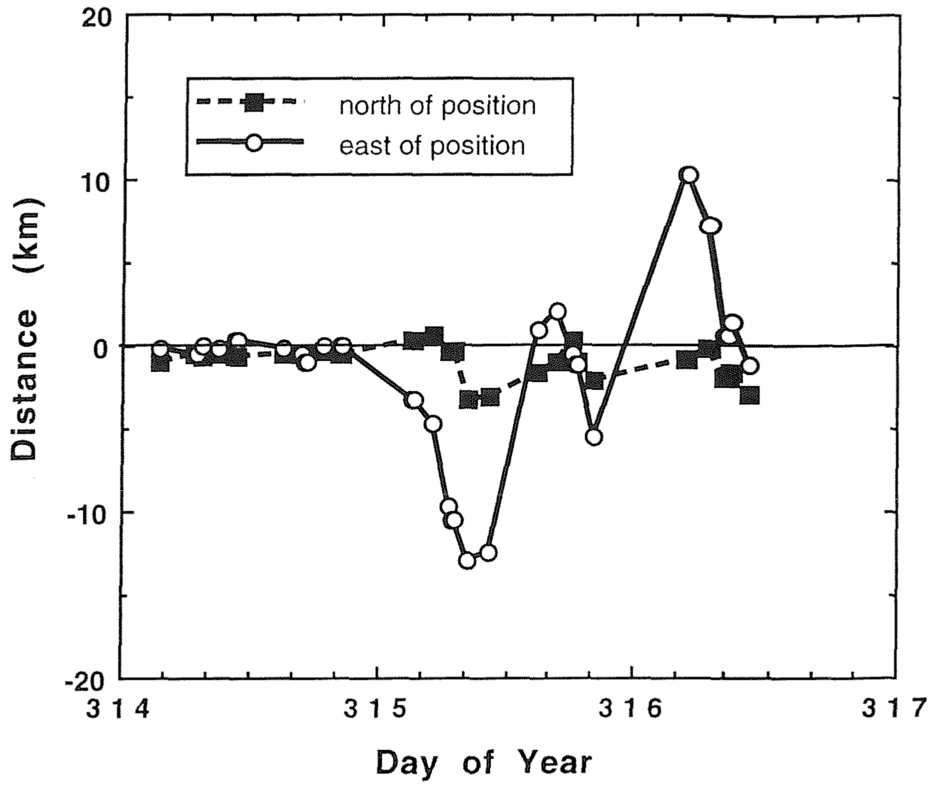


Figure 4.12 Distance of the Waverider from the nominal mooring position during the period when it was adrift. The buoy initially drifted to the west southwest and returned close to each original position with each tidal cycle.

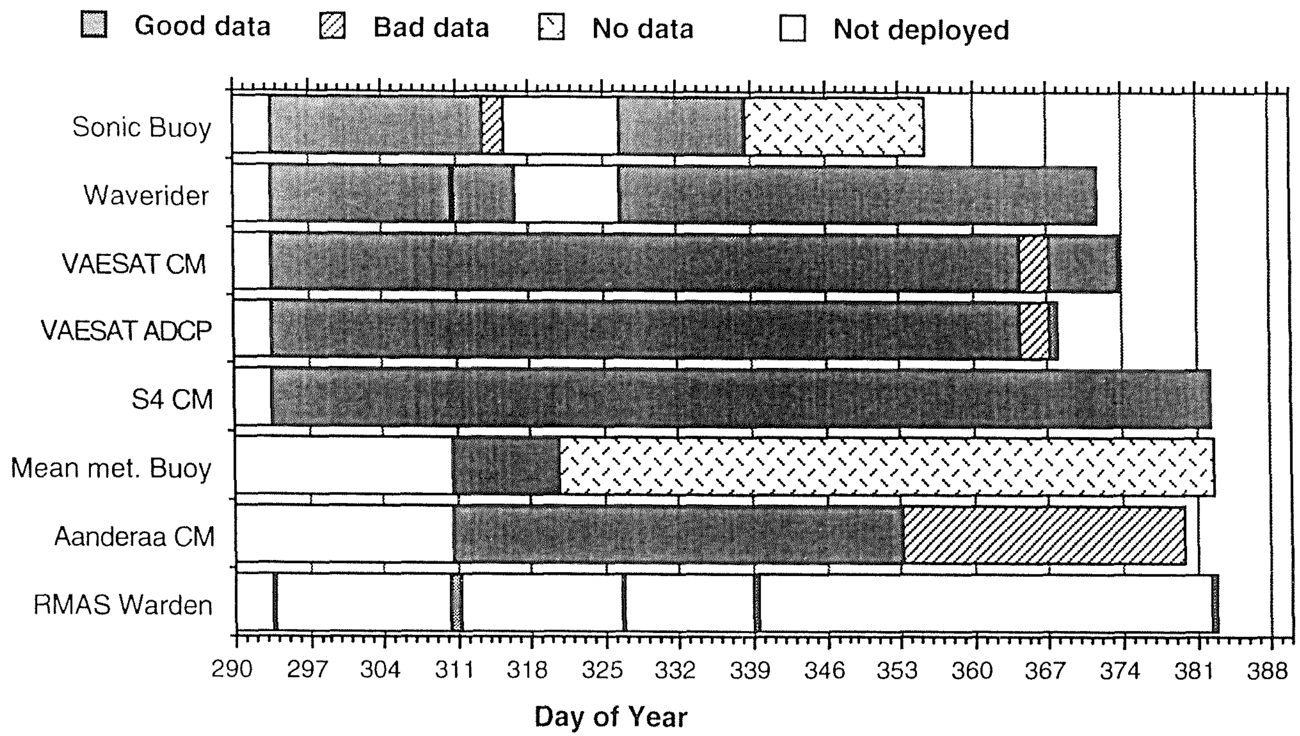


Figure 5.1 **Summary of the data collection periods for each buoy. Also shown are the times that the RMAS Warden was used to make meteorological measurements in the area of the buoy array.**

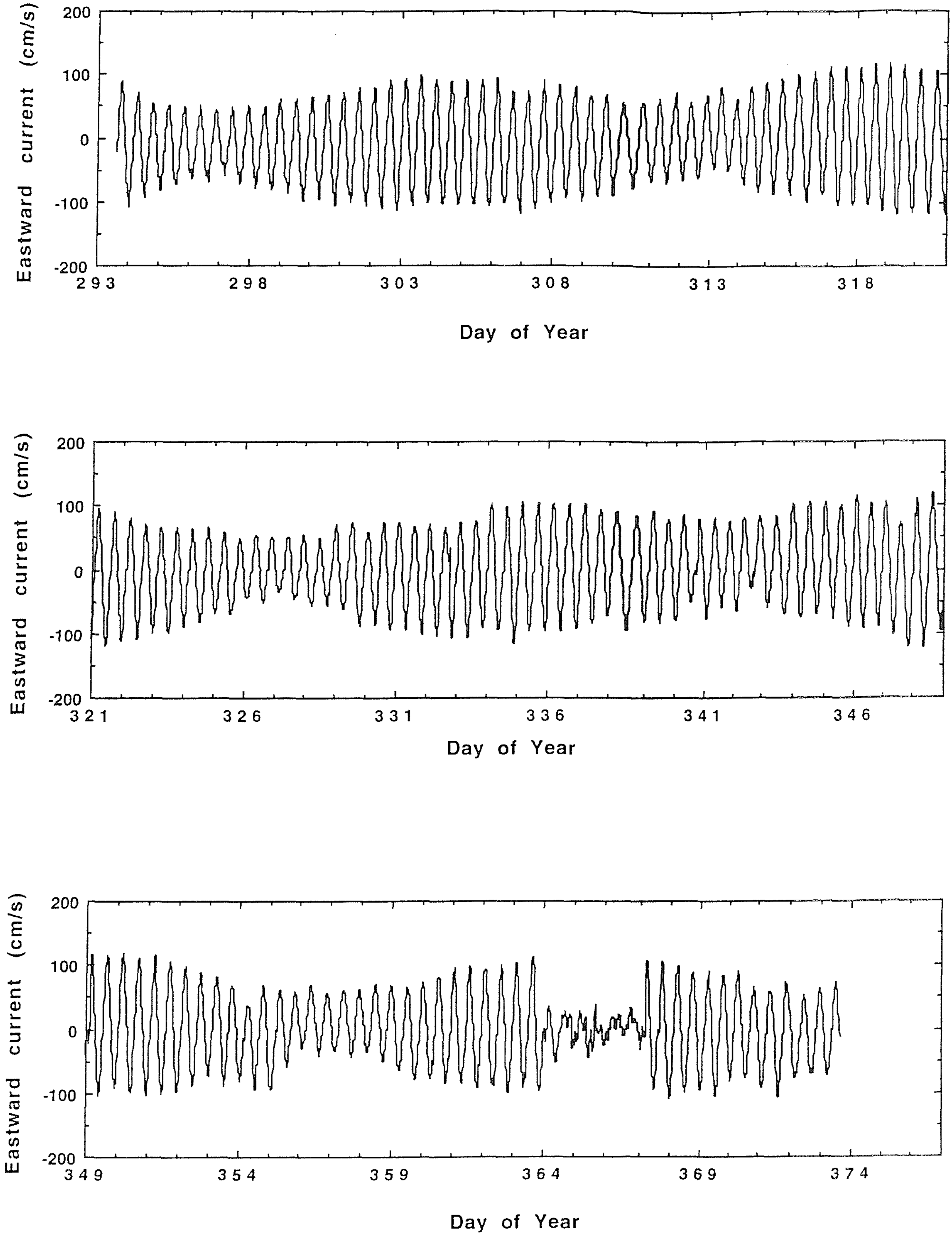


Figure 5.2 **Eastward current components (cm/s) from the VAECM instrument on the VAESAT buoy.**

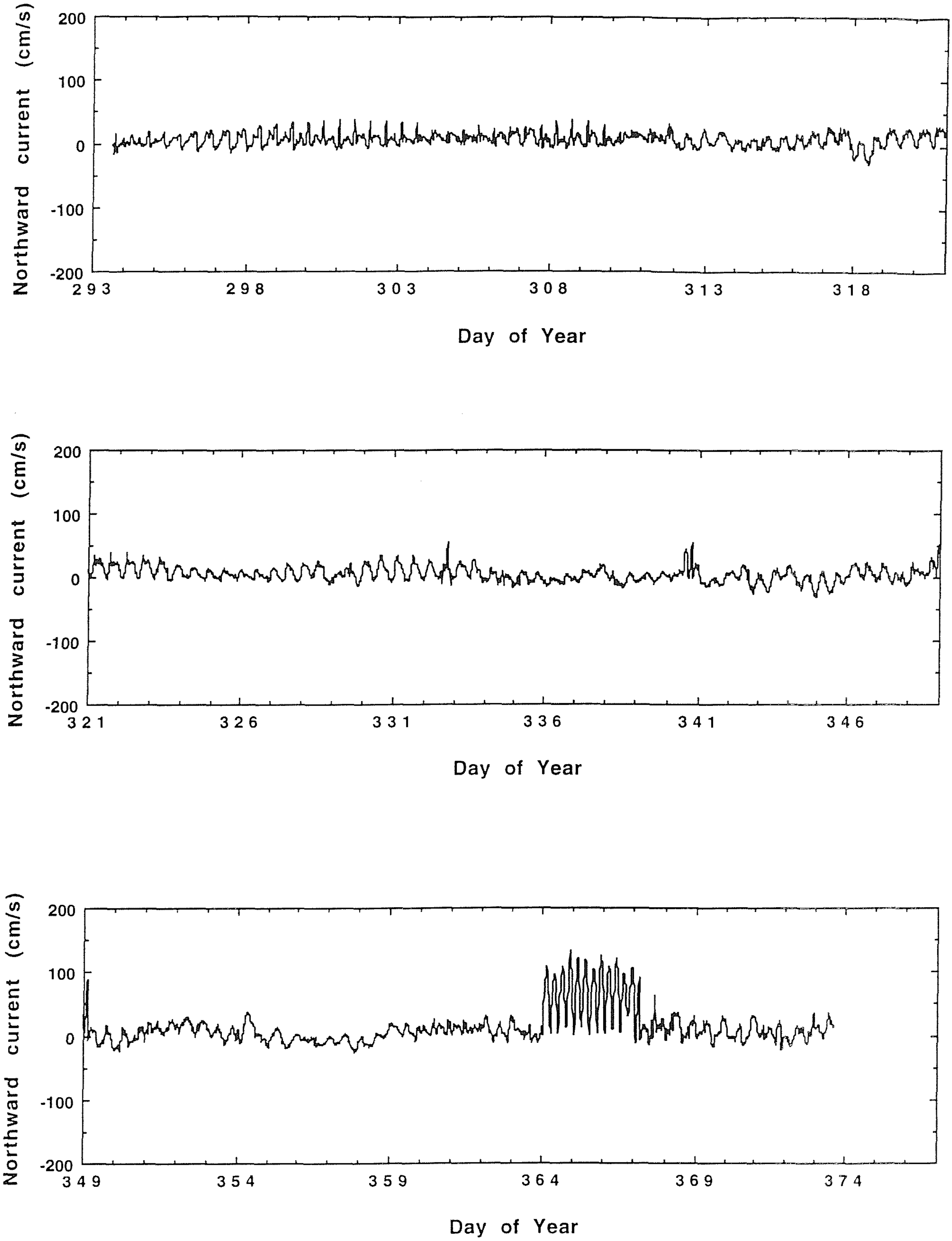


Figure 5.3 **As Figure 5.2 but for the northward component.**

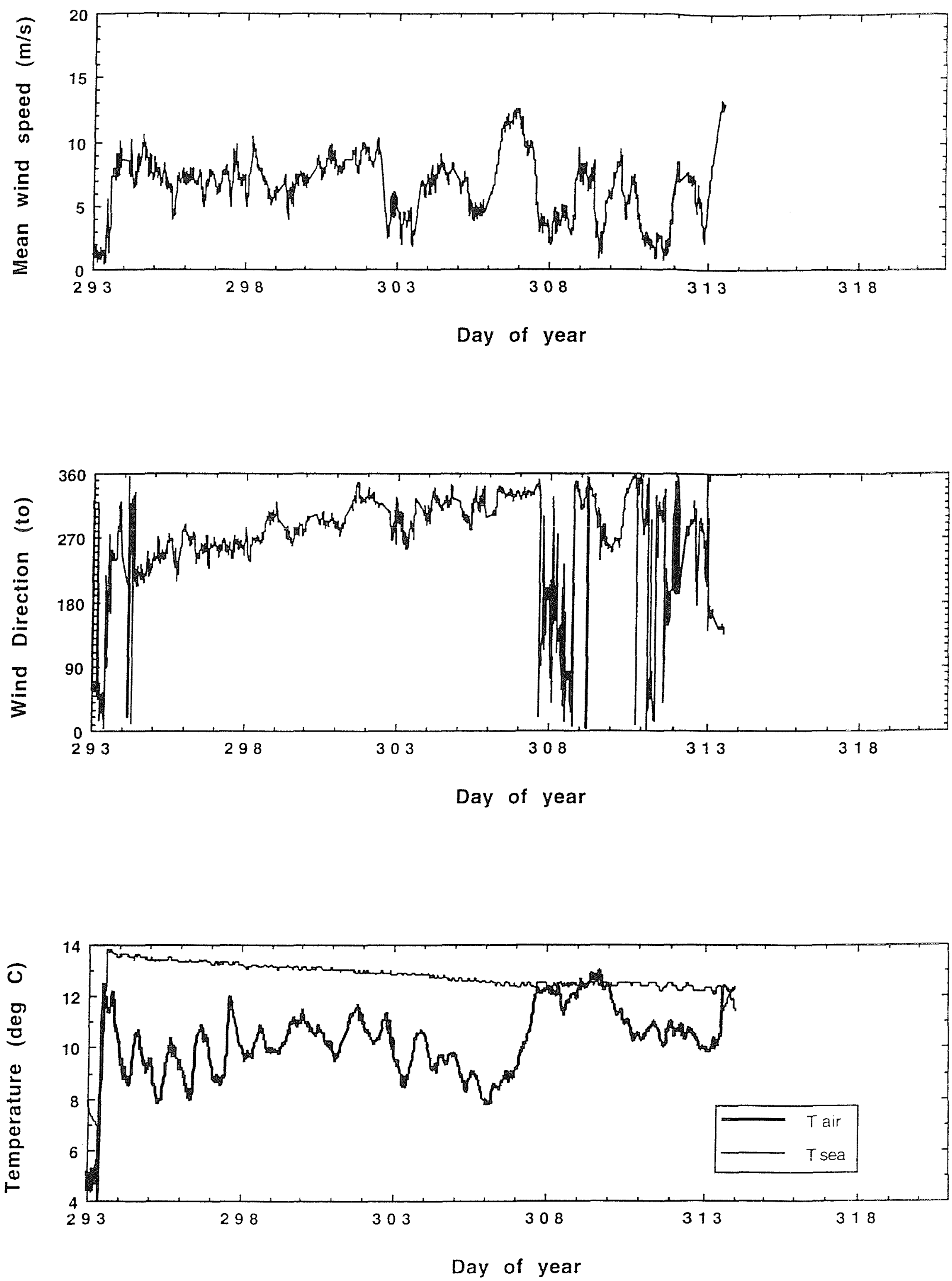


Figure 5.4 Mean meteorological data from the Sonic Buoy during the period day 293 to day 321. From the top the plots show: Mean wind speed (m/s), the direction to which the wind was blowing (degrees), the air and sea temperature (°C).

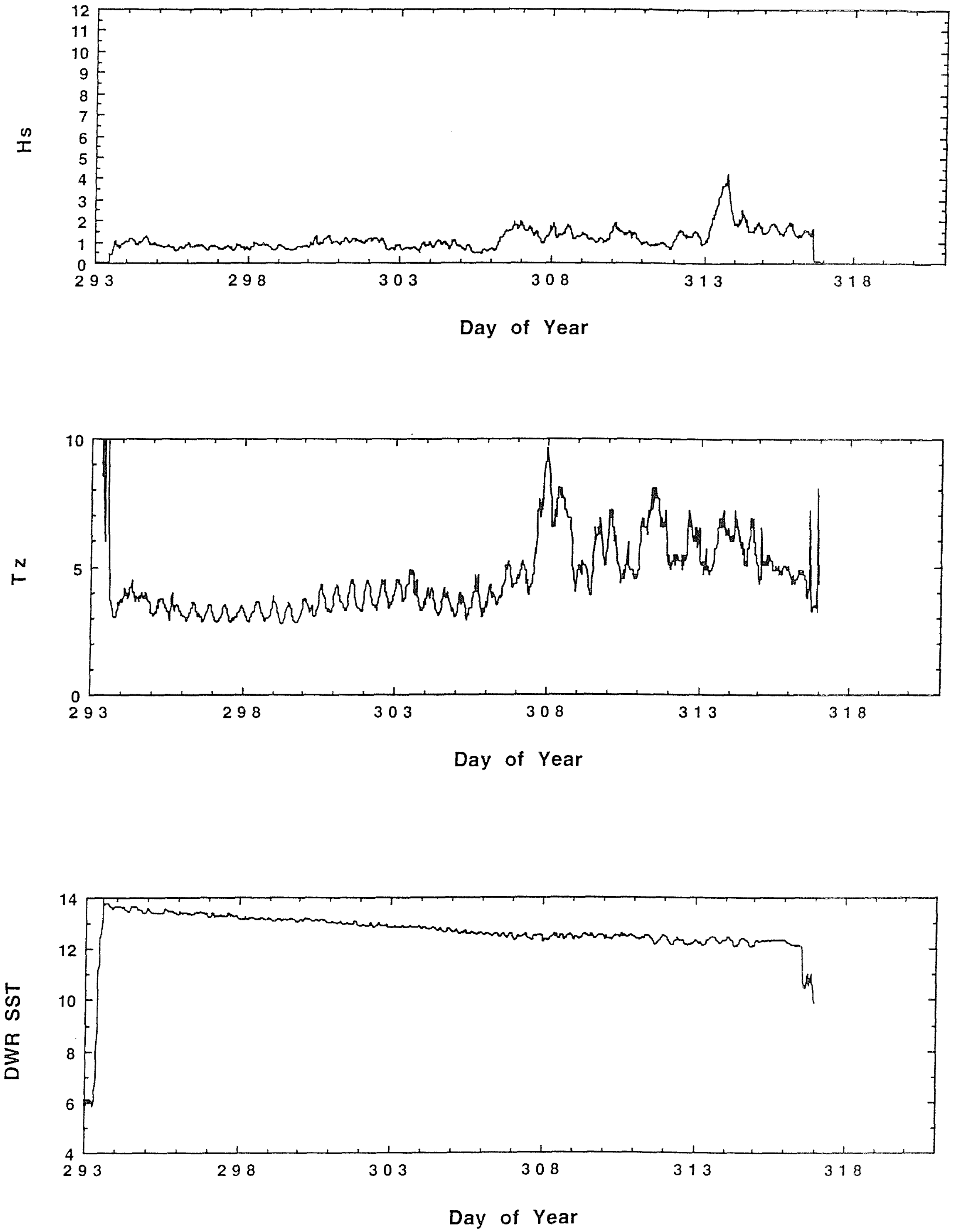


Figure 5.5 Mean wave data from the Directional Waverider during the period day 293 to day 321. From the top the plots show: Significant wave height (H_S m), zero crossing period (T_Z secs), and the sea temperature (°C).

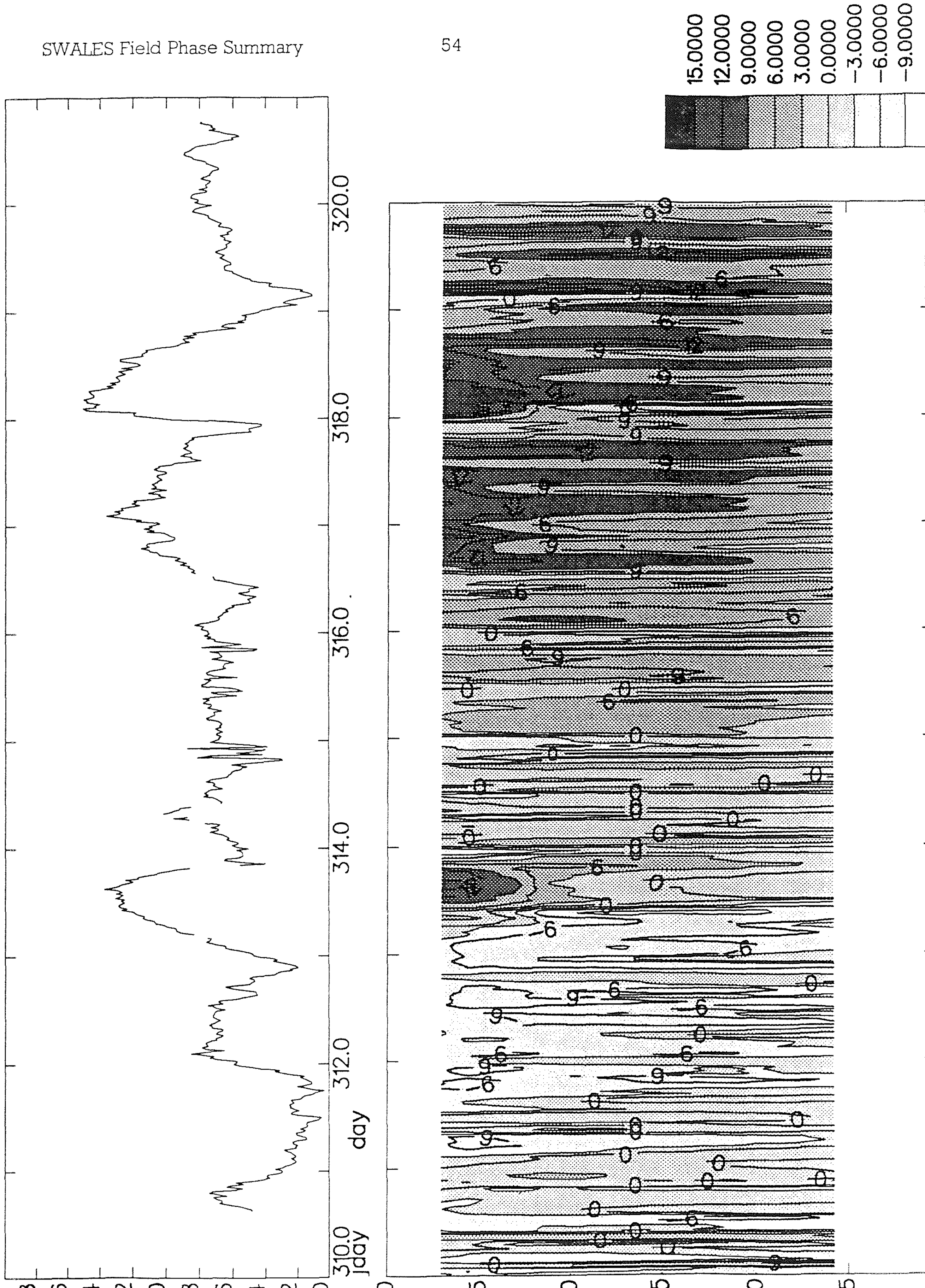


Figure 5.6 Examples of data from the Mean Met. buoy and VAESAT, dats 310 to 320
(a) wind speed from the mean meteorological buoy
(b) relative amplitude of the ADCP instrument plotted as a function of time and depth.

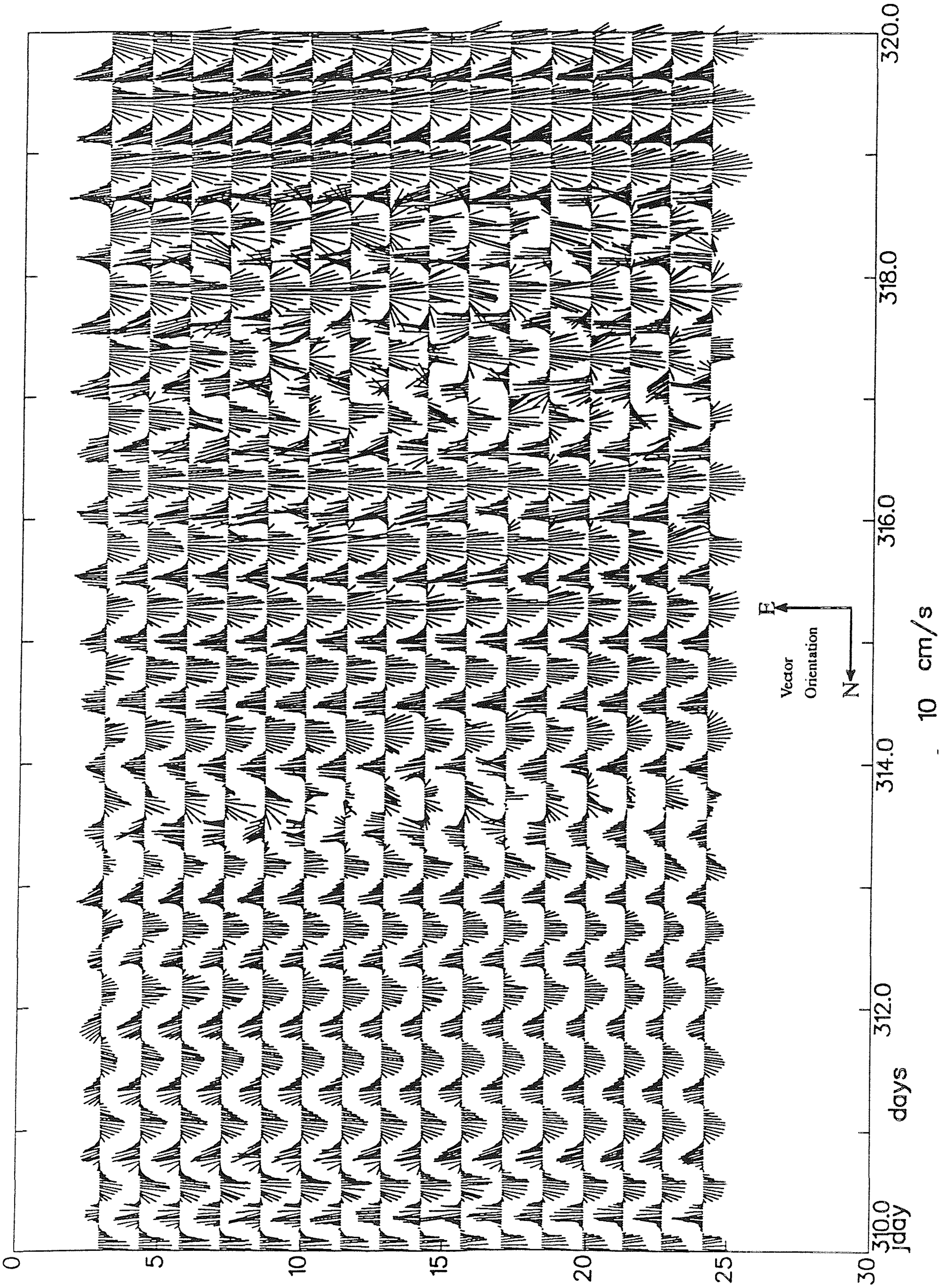


Figure 5.7 Examples of current profile data from the ADCP on the VAESAT buoy, days 310 to 320.

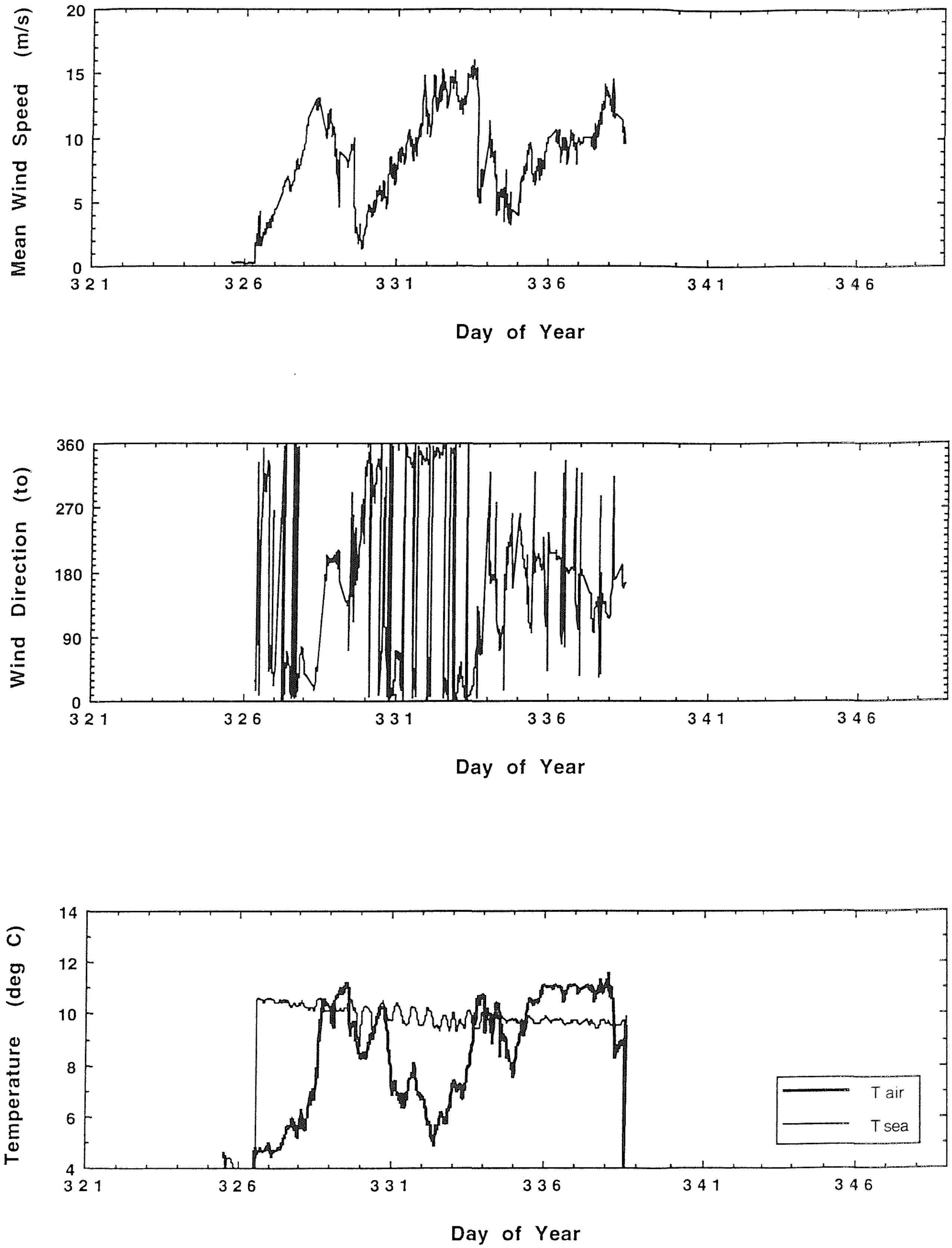
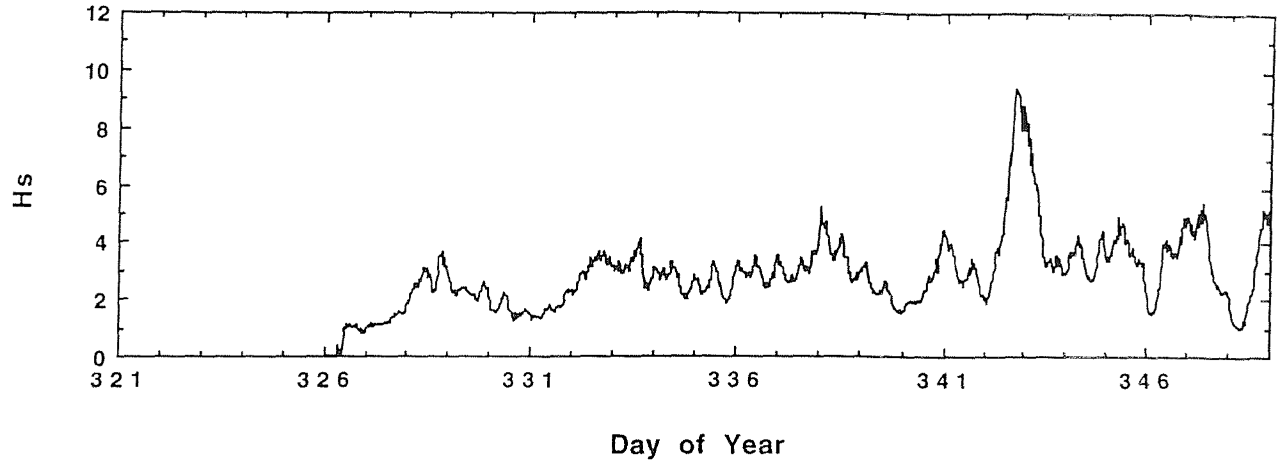
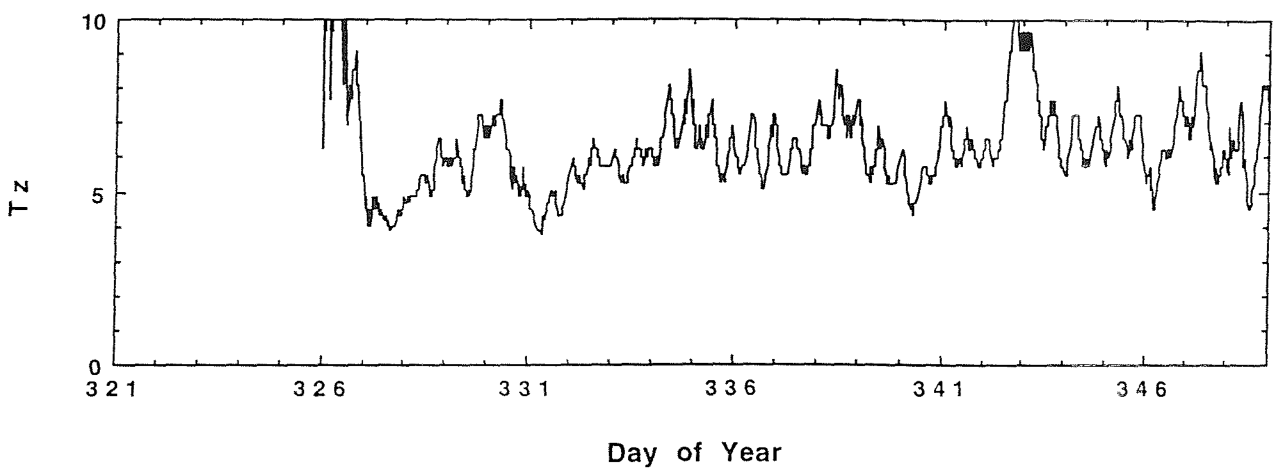


Figure 5.8 **As Figure 5.4 but for the period days 321 to 349.**





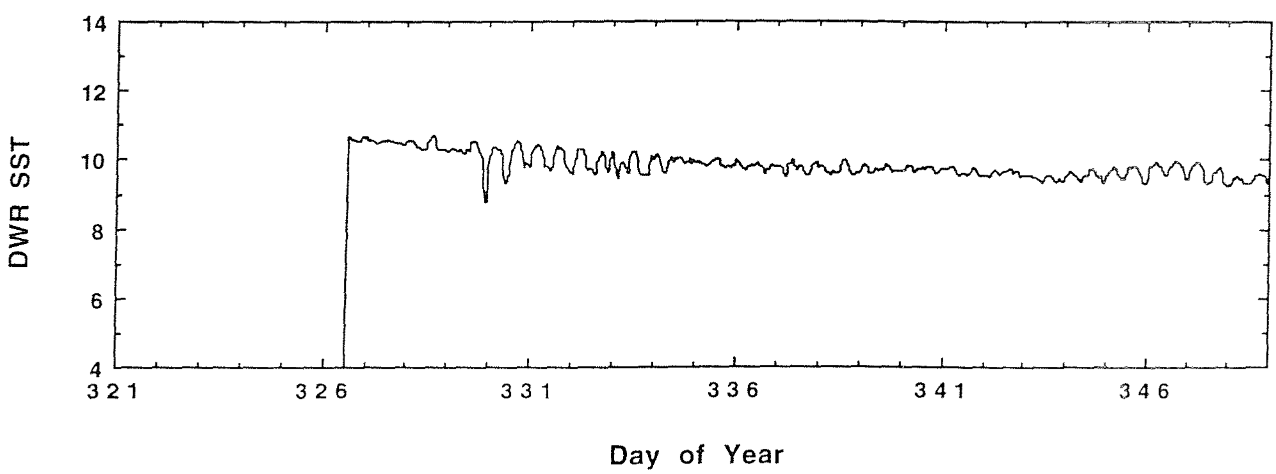


Figure 5.9 **As Figure 5.5 but for the period days 321 to 349.**

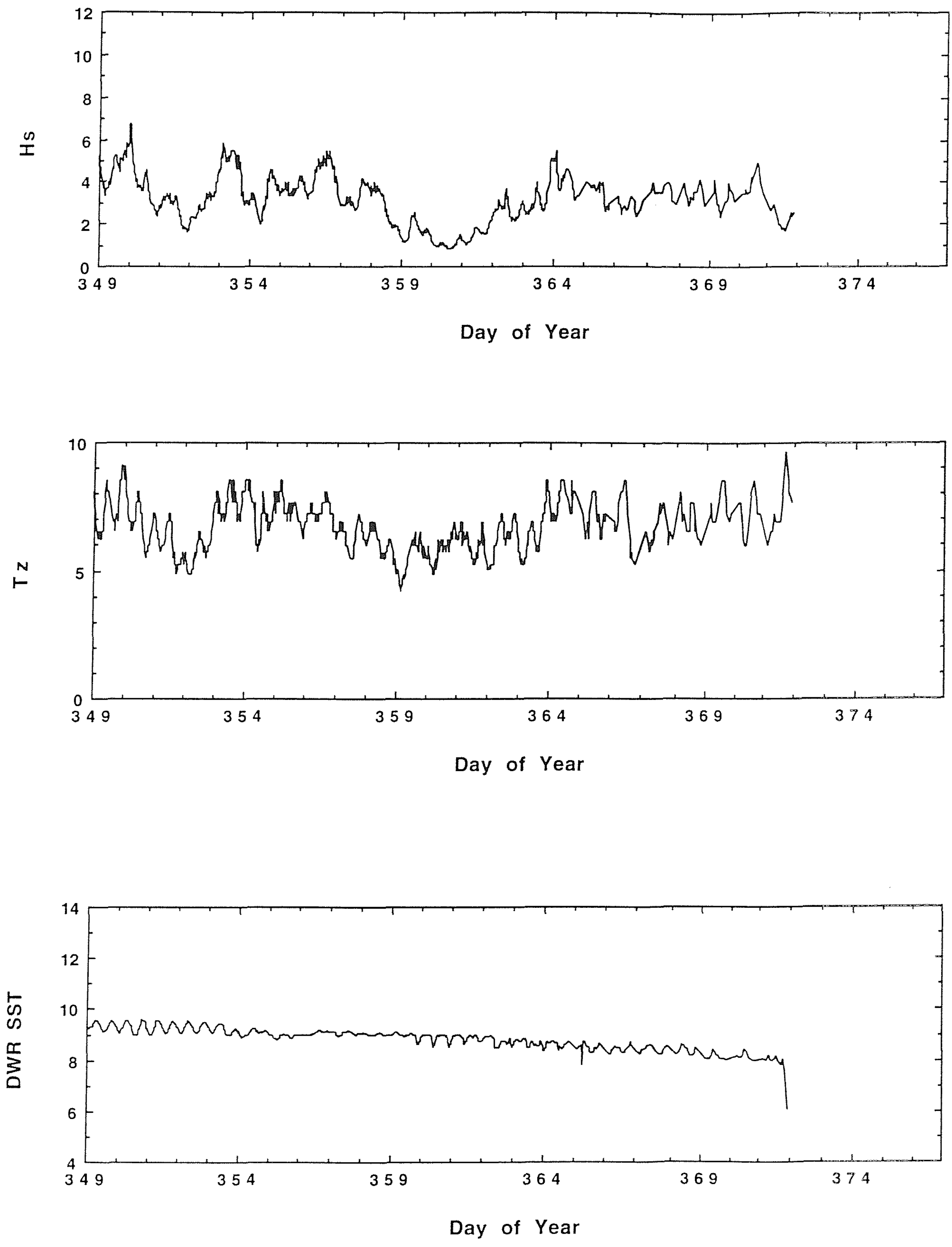
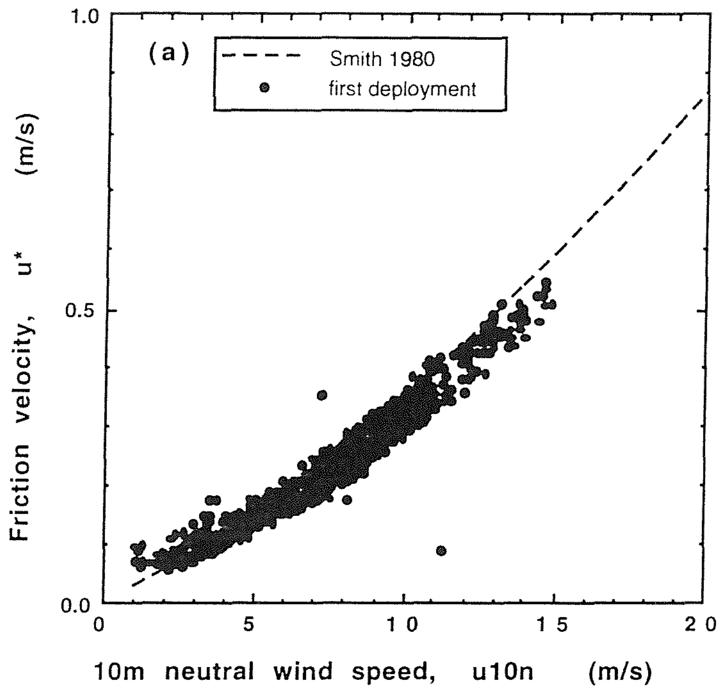


Figure 5.10 As Figure 5.5 but for the period days 349 to 377.



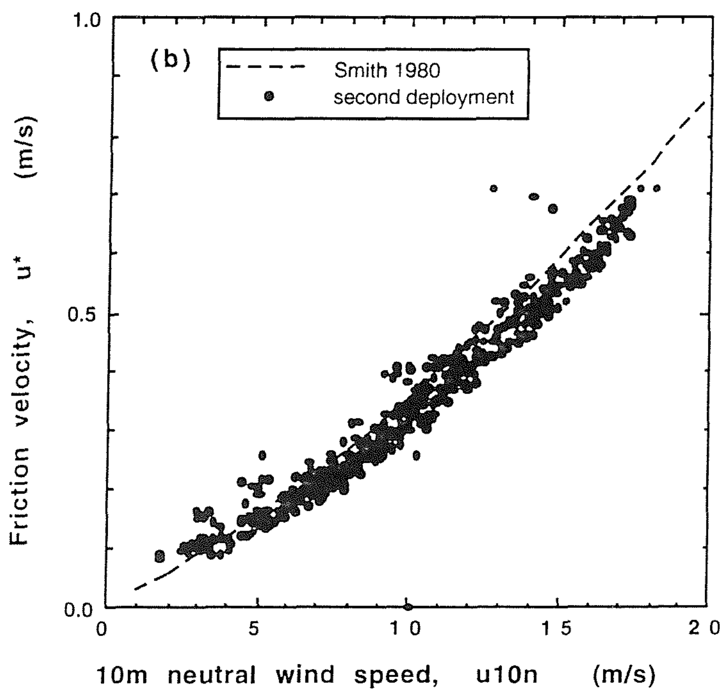


Figure 5.11 Values of the friction velocity, u_*, plotted against the wind speed (corrected to 10m height and neutral stability), u_{10n}. Data are shown from the Sonic Buoy for (a) 1st deployment and (b) 2nd deployment. Also shown is the formula of Smith (1980)

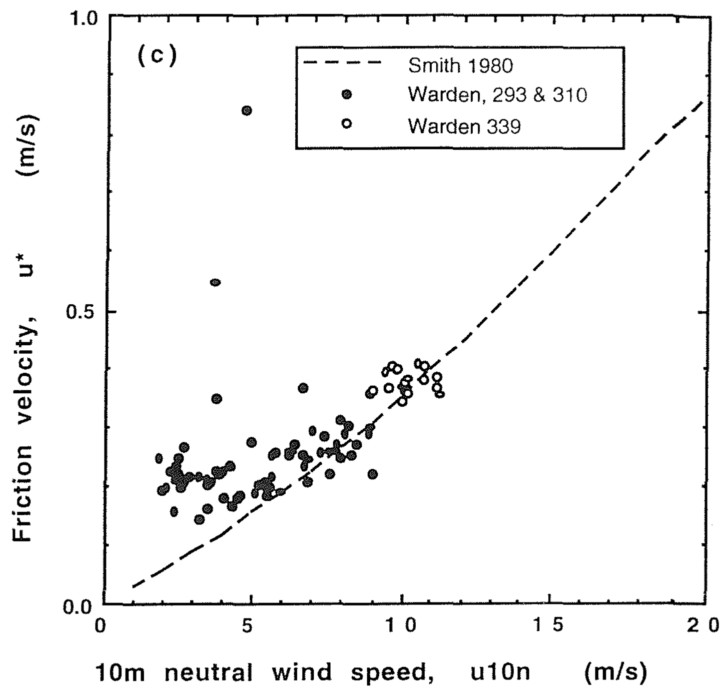


Figure 5.12 **As Figure 5.11 but for data from the Warden.**

APPENDIX A. VISIT NOTES FOR FIELD WORK DURING EXPERIMENT

A.1 Introduction

This section reproduces the "Visit Notes" which report on the fieldwork done during the SWALES experiment. The notes are reproduced as written except for minor editing mainly to save space.

A.2 Deployment 18 - 21 October 1993 (291 - 293) Margaret Yelland

A.2.1 Personnel

Moorings:- Ian Waddington, Keith Goy, Stirling Aldridge
Instrumentation etc.:- Charles Clayson, Keith Birch, Robin Pascal, Margaret Yelland

A.2.1 RMAS Warden Mobilisation (291 - 293)

The IOSDL 10 m meteorological mast could not be welded to deck as planned. A plate was attached to the deck by chaining it to eyebolts around the wall?, and the mast base was welded to the plate. It was noticed that the plate was flush with the deck rather than horizontal, which meant the mast would tilt towards the stern when fitted. To rectify this, strips were welded along the sides of the plate to bring it horizontal. When the mast was lowered by crane it would no longer fit between the jaws of the mast base. The jaws were prised apart and a bar was welded between them on the forward side to keep them open. When the mast was later successfully lowered into place it landed on the cable from the sonic, crimping it slightly. The mast was lowered back until the top was within reach of the monkey island and the sonic anemometer (0038) was fitted with the clear window forward. (0038 was meant to be the spare for the buoy (carrying 0062 at present), so if third anemometer (0089) is needed for the buoy it should be wind tunnel tested first). Two psychrometers were fitted to the carriage on the mast (73 on the port side and 72 on the starboard) which was raised to the level of the lowest shrouds, i.e. about 2/3 the way up the mast

The GPS, MultiMet and Sonic fast sampling systems were installed on the bridge. The Waverider, Current , Sonic Buoy and VAESAT moorings were lifted onto the aft deck along with the ship mooring. During tests it was found that the Meteosat system on the Sonic Buoy was not working due to the failure of the high power amplifier. The Meteosat system was not essential and its failure did not affect any of the other systems on the buoy, so it was decided to remove it.

A.2.3 Mooring Deployment from RMAS Warden (293 - 294)

The Warden left Pembroke Dock at 1100 GMT on Wednesday 20th October (day 293) and arrived on station at 1330. While on passage the GPS and compass were compared to the ship's systems; at 1310 the "quality" numbers were 511. Ships position 51 30.41N 4 52.13W cog 107, our GPS cog 100 (magnetic variation?) and position 51 30.39N 4 45.00W.

Once the Warden was on station it was held stern to wind while the Sonic Buoy was deployed. This was successfully completed by 1400 at 51 29.6N, 4 45.54W ship, 51 29.58N 4 45.57W IOS. The ship used DECCA to find its position and placed the Sonic Buoy "to 1 cable" (~200m). The tide was running at ~0.5 knots 30 min before low tide and the water depth was

40m. The VAESAT was deployed by 1450 in a depth of 42.5m on position 51 29.54N 4 45.22W. The Waverider was deployed by 1530.

While the acoustic releases for the current mooring were being tested, the new SST sensor was deployed over the port beam at 1545 and brought in at 1621. It was not left unattended since the ship's officers were concerned about the bow thruster intake situated near the position of the SST. Three bucket sea temperatures were obtained between 1600 and 1605, which all read 13.6 degrees C. The thermometer used was MET 21500 and had not recently been calibrated. At (15:20 ? BST) 1620 the sonic analogue channels were plugged into the MultiMet logger. At 1638 the ship went hove-to while waiting for the acoustic releases to be mended. The SST was deployed again at 1642 and bucket temps were obtained which remained at 13.6.

By 1830 the acoustic releases were declared unfixable. Eight sonic spectra had been obtained at wind speed of ~7m/s. The ship's master informed us that if the Warden did not leave promptly then she would have to remain out overnight, due to tide/current restraints when docking. Since the wind speed seemed unlikely to increase, and because of the lack of accommodation for four of the five IOS team, it was decided to return to Pembroke. Cost was another factor in this decision, since there would not be enough time in the 24 hour period to deploy current mooring (if releases repaired) or to deploy ship mooring (if this decided to be worthwhile).

The ship mooring was not deployed because it was decided to be a hazard to shipping without a light being fitted first. After conversation with the ship's master it also appeared that the mooring would more hindrance than help in keeping the ship hove-to on station. As long as the SST is not deployed, or is kept well away from the intakes, then the Warden can hold position very well using the (non-directional) bow thrusters.

On passage back to Pembroke the MultiMet data was checked. The psychrometers were all in close agreement which indicated that the wet bulbs were not being wetted properly. The v analogue channel from the sonic was very low, reading -26 m/s. The Warden arrived at Pembroke at 0930 GMT (day 294). Problems were noticed when downloading the MultiMet data. Jday seemed to have been corrupted, possibly due to the power surges when changing from shore to ship power. This could be solved using an uninterruptable power source (UPS). The GPS date was 14 days out (slow?) and was reset to 295 (NB this appears to be wrong)

A.3 Shore Visit 28 - 29 October 1993 (301 - 302) Margaret Yelland

A.3.1 Personnel

Peter Taylor, Margaret Yelland, Elizabeth Kent

A.3.2 Shore Station (301)

Stopped logging at 1510/301, started backup at 1525, finished by 1710. Difficulty in using tape left in hut probably because of the cold. A warm tape worked. Last file backed up was 10281512.UDT (mmddhhmm). After backup clock had slowed 46 minutes, was reset to 1713.

Restarted logging - first file logged is 10281714.UDT.

A.3.3 RMAS Warden Port Visit (302)

Ship was visited in Pembroke on day 302._GPS sytem was not logging to c:\data i.e no N* files (long?) are recorded, but do get G* (short format?) data on floppy disk.

Sonic fast sampling data was ok except for a lack of .mws files after 2931945.

The MultiMet data could not be backed up due to an address problem on the Eprom(?)

Date and time was checked on all systems. Multimet date was reset since it was giving a day "1F" (supposedly in decimal!).

Spoke to Richard Morris who agreed to give an estimate on costs after each period of ship time. Agreed with ship's master that he would call JRC directly when Warden passes buoy array, and that we can call the ship direct. A bucket and thermometers were left on the bridge for use by the crew when taking "opportunistic" measurements. When the question of lifejackets was brought up it transpired that although the crew are provided with them, the lifejackets are to bulky to be worn when working on deck. Any IOS staff involved in ship work should bring a lifejacket of their own.

A.4 RMAS Scarab Waverider check 29 October (302) Ian Waddington

A.4.1 Interference by fishing vessel AILSEA (300)

At 1730h on the 27th of October (day 300) a phone call was received at IOSDL from Milford Haven Coastguard. This call was passed through to I Waddington. The coastguard was in contact with the fishing vessel AILSEA, call sign MNVA8, which appeared to have fouled a mooring at the SWALES site. The fishing vessel had determined whom to contact from the IOSDL phone number on the buoy. By talking through the coastguard I established the exact description of the buoy to determine precisely which mooring had been fouled. The surface buoy described was that of the 3D Waverider. I then determined that the AILSEA had been fishing a 15 fathom bottom trawl with doors and that the trawl appeared to be fast and not recoverable by the vessels winches. I ran through the mooring design and layout with the coastguard and gave details of the weights and type of anchoring on the mooring. During further discussion I overheard the AILSEA had not seen the Notices to Mariners posted and had trawled close to the outside of the 3 buoy array.

The AILSEA was at this time reporting that he had attempted to steam courses away from the buoy and had been unable to clear his trawl. He requested advice on possible methods of clearing from IOSDL. My only suggestion was that he steam off to one side away from the array and free his warps and dhan them off as there would be no safe way to recover his gear from the Waverider buoy. I considered any interference with the buoy to be a hazard to the delicate electronics and exposed ARGOS antenna. The AILSEA then agreed that this was the only course open to him as his vessel was pounding in the seas and presented a hazard to his crew. Before he called off the line I asked that on completion of paying away his warps that he check that the Waverider was still securely moored and that the skipper call IOSDL in the following morning. I then subsequently contacted Keith Birch on the Mobile phone outlining the problem and suggested he attempt to contact the AILSEA by Ship to shore through Portishead.

I received a call at around 1015h on the 28th of October from the skipper and had a brief discussion on the fouling of the mooring and as to how he had buoyed off his warps. As the skipper was in a call box I then contacted Keith Birch who took over the call.

A.4.2 RMAS Scarab Mooring Inspection, 29th October (302)

Arrangements were then made for RMAS Scarab to go to the mooring and attempt to free the trawl from the mooring on the 29th of October. Ian Waddington drove to Pembroke arriving at 0730h on the 29th, meeting Peter Taylor at Pembroke who had the key for the IOSDL container. A complete spare mooring was transferred from the container to the SCARAB and the vessel put to sea at 0900h. On clearing the headland it was apparent that the wind and sea were easterly and the vessel made heavy weather of steaming towards the site. At 1100h the captain hove to into the sea and it was apparent that it would be hazardous to handle the Waverider buoy alongside without damaging the exposed antenna. Also launching of the vessels workboat would not be possible.

I insisted that the SCARAB should make for the mooring site and complete an inspection of the buoy at the very least. The vessel increased to full speed and proceeded to the site.I maintained a radar watch on the approach to the site. At a range of 3.5 miles I detected the SONIC buoy on the vessels radar. Cross checking the navigation and deployment position confirmed the buoy's identity. The vessel altered course to the buoy and proceeded with caution. The buoy was seen visually at 1 mile range with poor binoculars. As the vessel closed the SONIC buoy a close watch was kept for the Waverider and any fishing markers. The fishing markers were identified as a 2m dhan buoy and two inflatable 24" floats. The DWR was inspected closely at 1155 and could be seen to be floating correctly with the bungee occasionally visible. The fishing floats appeared to be at a distance of 200 metres from the buoy and well streamed out clear of the mooring.

With the sea state precluding launch of the workboat no attempt could be made to recover either the WR or the fishing floats. The captain stated that he could not guarantee to hold position alongside the fishing floats and with heavy steel warps presenting a hazard to the vessels propeller no attempt at recovery in the conditions could be made. The vessel stood by for 30minutes on site and the SONIC and VAESAT buoys were inspected. A clear berth was given to the buoys with the vessel off to one side such that the wind flow would not be interrupted by the vessel. Both buoys were floating correctly and all wires and ropes were as placed on deployment. The vessel turned for Pembroke at 1230h and with a following wind and sea made best speed. The vessel was alongside at 1530h/302. A verbal report was made to Peter Taylor on the dock for passing to Keith Birch by mobile phone.

A.4.3 Comments and recommendations.

It is difficult to determine whether the fishing gear is actually fouling the mooring or is fast to some other obstacle. On deployment a string of crab pots was identified off to the WR side of the mooring. This could indicate foul ground, rocks, which the trawl is fast in. Or alternatively this string could be a whelk string which would indicate a shingle bottom, in which case the trawl is fast in the anchor of the mooring. I have checked with a trawler skipper friend who was surprised that the AILSEA could not raise a 400 kg anchor with his gear or free himself from the plough anchor. However this is based on supposition as to the AILSEA's gear.

The limiting factors preventing recovery were, firstly the sea state prevailing preventing launch of the workboat to recover either the Waverider or the buoys, and secondly, the danger to the exposed ARGOS antenna on the IOSDL buoy if an attempt had been made from the vessel.

Recommendations are:

1. I cannot say if the DWR mooring is fouled and it would be advisable to clear the fishing gear if at all possible at the earliest opportunity.

2. The antenna on the DWR is too vulnerable to damage either from a recovery vessel or even an inquisitive vessel. Would it be possible to fit an IH type ARGOS antenna contained with the light assembly for future applications?

3. If the AILSEA is to attempt to recover his own gear it might be advisable for an IOSDL person to go to observe attempts and to verify that no damage is done to the DWR. The AILSEA should be prepared to recover the DWR if any mooring damage is suspected. They should be advised of the weight of the buoy and its delicate nature.

4. If the WARDEN is to recover the DWR/fishing gear the above should apply and it should be determined that a workboat can be launched to recover the DWR before any other operation is attempted.

A.5 Shore Visit and RMAS Warden 5 - 7 Nov. (309 - 311) Peter Taylor

Personnel: Peter K. Taylor

A.5.1 Shore Station visit (309)

0930 stopped logging last = 11050929.UDT
files occupy 283512056 bytes, 210665472 bytes free (i.e just over half disk used)
files before 1028tttt deleted

0950 backup started first file = 10281714.UDT
inspected mast - top but one section (carrying preamp box) had retracted, mast lowered to re-erect.

1145 backup finished; 2 tapes used (just almost whole backup fitted on one tape); checked could read directories

1230 mast re-erected - logging restarted (11051150.UDT) then stopped to set time correct
restarted logging file= 11051253.PDT

1300 monitor off, closed box.

A.5.2 RMAS Warden Port visit (309)

1730 Warden berthed outside HMS Norfolk

1745 all systems appeared to be running following switch to shore power, however no needle was on compass display before (or after) this change over.

Fast sampling: dumped fast sampling, 3 disks needed; time on fast sampling NEC was two minutes fast, reset 2057 fast sampling restarted at end of visit checks

Slow sampling: data looked OK except psychrometers:

	Port	Starboard
Dry	12.9	-17.52
Wet	11.7	-17.05

disconnected and reconnected starboard psychro plugs but no change
MultiMet eprom status - boards=3, extra chips=0, bpr = 200, next free = 174D1C Hex
start file = MM30202, address 140A07 Hex
good data from 9310291449 to 9310311411, then data all FFFF's
MultiMet clock date = 3F, reset

2033 carriage to top of mast

2040 following phone call to Keith, logger set to BPR=68, new file opened MM30901, next=174D1C

2044 data checked using shipmet1

GPS: logging to G3091605.DAT, needle off compass, system hung; files before day 300 deleted, newer files backed up; GPS rebooted, logging to G3092021.DAT

All systems: connected via UPS unit (before resetting EPROM logger parameters)

A.5.3 RMAS Warden charter (310 - 311)
Personnel: Ian Waddington, Moss, Peter Taylor

Passage out (0900 to 1200)

0810 Personnel join Warden; gear being transferred from RMAS launch

0900 cast off, anchor weight and met buoy picked up from moorings

0930 all gear on board, begin passage

0933 fast sampling stopped to check SST sensor, couldn't get signal until MMet to NEC monitoring cable resoldered (black lead had broken)

1034 10m mast carriage lowered, SST sensor and Assman psychrometer mounted close to port MMet psychrometer.

Time	SST probe	Port Dry	Assman	Comment
1034	12.5	11.8	12.4	
1036	12.6	11.8		
1037	12.8	11.9		
1040			12.6	
1042	12.4	12.2		
1043	12.2	12.2		
1046			12.4	
1047	12.2	12.0		
1048	12.1	11.9	12.5	
1049	12.1	11.9		
1051	11.7	11.8		(1050 rdg not displayed)
1052	11.9	11.7		
1053	11.9	11.7		Stopped - spray starting to come over bow, SST probe might be wet
means	12.2	11.9	12.5	

1104 carriage raised to shroud plate

1114 fast sampling restarted

Attempt to recover trawl net (1200 to 1330)

1205 at moorings, hove to wind 5 to 7 m/s

???? Gemini launched

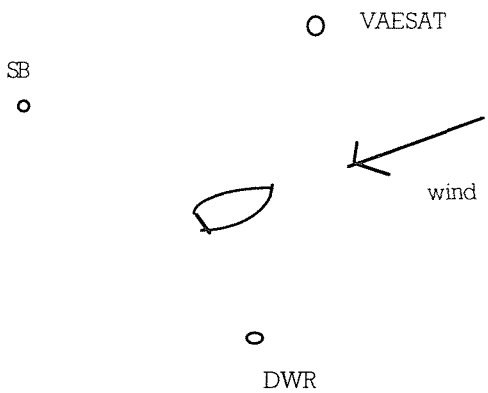
1225 manoeuvring to pick up trawl float

1250 blue rope to trawl stretching vertically down from stern of ship - parted; ship turning to inspect wave rider

1305 wave rider mooring found taught (about 1 knot current); Gemini recovered

Anchored while Met buoy prepared (1340 to 1440 and on to 1500)

1340 ship anchored, wind 5.3m/s, wind on bow, ship heading 102T, current with wind



our GPS	51 29.407N	4 45.339 W
ship GPS	51 29.426N	4 45.298 W

1354 SST probe deployed from Port bow
(1405 Bucket SST = 12.3) (1411 wind 5.8m/s) (1415 bucket SST = 12.5)
Engine intake was measured as 13 degrees with probe which reads in whole degrees. This was at about 6' from intake at sea chest.

Met Buoy deployment (1440 to 1504)

1440 activity commences, ship still anchored, head to wind (5.9 m/s) (see appended fig for final mooring configuration)

1445 buoy in water, Aanderaa anemo cup broken by staying line during deployment; current = 0.8kt from EM log

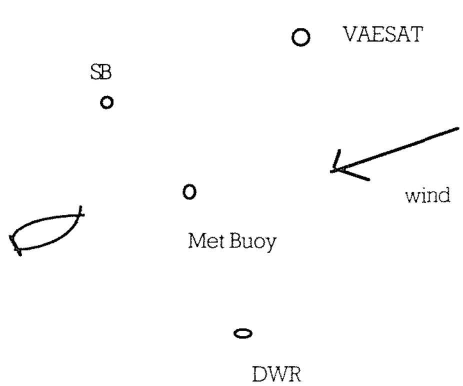
1451 subsurface float in water

1455 mooring anchor let go as ship winched forward on its own anchor

1457 SST probe out of water, wind 5.7 m/s

1500 compass cal checked as 818

1504 ship turning to drop downwind of moorings



Hove to waiting for slack water (1505 to 1545)

1514 head to wind (117T)

1519 SST probe deployed
(1526 wind 5.5m/s) (1540 wind 5.47m/s)

1545 SST probe in board, manoeuvring to inspect wave rider

Waverider inspection and re-deployment (1545 to 1700)

1550 Gemini launched (sea about 4 secs, 1m, from 110T)

1610 attempting to tow DWR clear, bungee parted

1624 DWR on deck, new mooring being prepared

1652 DWR lowered into water

1654 DWR anchor let go

On station downwind of buoys (1700/310 to 0400/311)

1716 on station downwind of buoy array ? soap deployed

1800 soap in? for manoeuvring back to position

1830 manoeuvring back to position

1840 back on station

1945 SST bucket (deployed 1930) = 12.4

1950 air temp (Assman psychro) = 10.4C

2000 DWR ARGOS message changed at 2001 gmt

2117 noticed that EPROM light on MultiMet logger was coming on once per minute - it isn't broken as we thought, just very faint so you don't see it in daylight.

Time	wind m/s	rel dir (approx)	gyro (true)	GPS compass (mag)
1800	7.1			
1940	8,6	340	110	
2010	7.6	0	105	113
2041	6.6	0	100	109
2110	6.1	0	101	111
2125	6.7	340	103	106
2140	5.3	340	102	106
0211	2.8	0	54	
0226	2.8	0	65	71
0241	2.8			
0326	3	010	70	76
0355	2.5			

Table - wind, gyro, and compass values while hove to overnight

2200 I went to bed; Ian stayed on watch till midnight

0207 wind now light, vessel had previously had to reposition at some time(s); buoys now on starboard beam

0211 GPS compass seems to be working but not giving data on COM2; reinitialised GPS with f5; disconnected power to interface box; compass display only recovered after using CTRL+ALT+DEL to reboot program; however...

0231 decided GPS receiver was stuck with only yellow light flashing; disconnected power and it then recovered. GPS system now logging to G3110232.DAT

0241 Note in these light winds (2.8m/s) spectrum still looks flat in 4 - 6 Hz region

0310 Bucket SST = 12.3 (bucket deployed at 0248)

0355 left station to start GPS compass check by rotating ship slowly

0426 start passage to Pembroke dockyard

0428 fast sampling stopped to dump data

0434 GPS stopped to format disks

0628 MultiMet monitored (Pdry = 9.65, SST (on deck) = 9.06, Pwet = 8.7, press = 1008, sonic u =-8.4, v = -23.9, w = -8.4)

0710 Sonic and GPS now running

0730 docked alongside HMS Norfolk

A.5.4 Shore Station visit (312)

1311 stopped logging - BACKPACK says general tape failure (tapes too cold?) waited till 1400 while warming tapes but no improvement so restarted logging

1505 stopped logging - still same error with now warm tapes; had to switch drive on and off several times before it worked; file SBRAW0711, several verify failures

1555 backup ended

1558 system restarted, clock seems OK, monitor off, backpack drive removed to take to IOS

1600 left hut.

Ship's gyro	GPS comp.	GPS - gyro
274	278	4
265	273	8
262	269	7
259	267	8
255	264	9
248	257	9
245	254	9
243	251	8
242	248	6
240	248	8
240	246	6
236	243	7
232	234	2
228	233	5
226	228	2
223	226	3
219	221	2
216	219	3
213	215	2
209	211	2
206	206	0
201	200	-1
197	202	5
196	196	0
192	195	3
181	187	6
176	179	3
172	176	4
170	175	5
167	171	4
163	167	4
158	161	3
156	160	4
151	157	6
146	153	7
141	146	5
137	140	3
134	140	6
131	137	6
127	131	4
125	131	6
121	127	6
119	124	5
114	120	6
106	116	10
102	111	9
99	105	6
97	106	9
90	97	7
86	95	9
80	89	9
75	82	7
72	78	6
70	77	7
67	76	9
60	67	7
56	65	9
54	62	8
51	58	7
47	55	8
44	53	9
42	49	7
41	47	6
38	45	7
34	39	5
31	37	6
27	34	7
24	30	6
19	24	5
17	20	3
14	19	5
11	14	3
9	12	3
6	7	1
4	9	5
2	3	1
0	4	4
357	3	6
355	359	4
351	353	2
349	355	6
345	351	6
340	345	5
336	341	5
331	332	1
327	332	5
323	331	8
319	326	7
316	320	4
313	317	4
310	314	4
308	312	4
306	313	7
304	310	6
301	307	6
299	306	7
297	304	7
294	299	5
291	297	6
286	295	9
282	290	8
280	288	8
276	283	7
272	281	9
269	278	9
267	276	9
266	273	7
265	272	7

Table - GPS compass and ship's gyro data

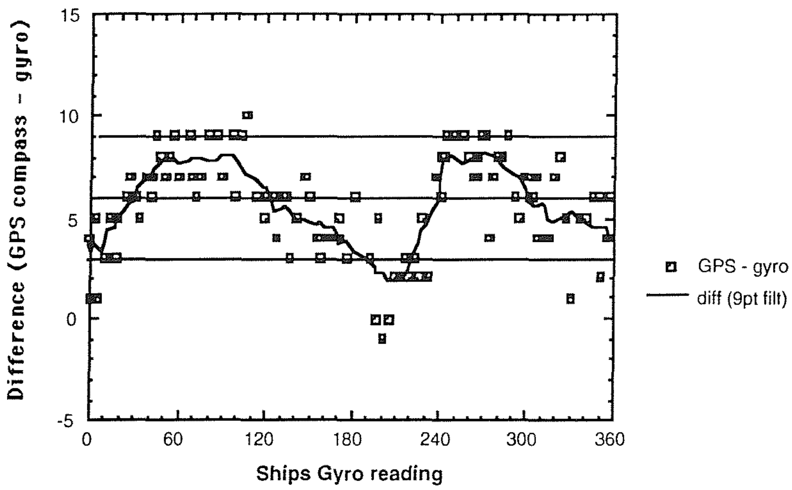


Figure - Error in GPS compass compared to ship's gyro. Observed points and a nine point running mean are shown. Lines show mean difference (6 ° magnetic deviation?) and ±3°

A.6 RMAS Halifax & RMAS Falconet 11 - 12 Nov. (315 - 316) Keith Goy

A.6.1 Sonic Buoy recovery (315)

The aim was to recover the Sonic Buoy which was thought to have capsized during poor weather conditions. Ian Waddington and Keith Goy left for Pembroke from Bognor Regis 0700 on 11th November, arriving at Tenby Harbour at 1245 to meet Keith Birch, Charles Clayson, and R. Pascal.

Transfer to the recovery vessel, RMAS Halifax, was by small boat from the harbour steps. During passage to the mooring site it was reported that the mooring had come adrift and it was planned that if time allowed we would attempt relocation and recovery prior to recovering the Sonic Buoy. Halifax arrived at the Sonic Buoy mooring at about 1400. The buoy had capsized and was floating upside down with the bridles leading over the hull. Plans to recover the were abandoned due to the time required to recover and tow the Sonic Buoy to either Tenby or Saundersfoot. With some difficulty, a line was passed through the towing bridle of the Sonic Buoy mooring and the buoy made fast alongside the Halifax. Attempts were made to work the boat along the mooring to allow the bridle to be hauled aboard and disconnected from the mooring line; this proved impossible due to the poor speed control of the Halifax at low engine revolutions. The mooring line was eventually severed using a knife on the end of a boat hook and the Sonic Buoy was led astern and made fast on the bollards. Attempts to right the Sonic Buoy were eventually successful and after rigging towing bridles the buoy was towed into Tenby Harbour at 1700, where it was craned ashore.

A.6.2 recovery (316)

Relocation and recovery of the was planned for the next morning, Friday 12th November (316), from the RMAS Falconet. This was delayed until 1200 due to delays in delivery of the Gonio Direction Finding equipment, sent by courier from IOS the previous evening. The Gonio was set up using power from a shaver socket and the antenna secured on the flying bridge. In order to calibrate the system with respect to the ship's head, the Falconet hove to approximately one cable from the VAESAT mooring and the Gonio zeroed with the ship's head pointing toward the VAESAT mooring. During the passage to the mooring site the ARGOS ID 7276 had been detected on the Gonio and the latest position fixes had been obtained from the ARGOS system by Peter Taylor at the JRC and relayed to the ship.

The was recovered, in a heavy swell, using the ships Effer crane and the mooring line recovered on board by hand. The lower rubber shock absorber had been cut at about 2/3 along its length and close examination showed abrasion in the vicinity of the break. This damage is consistent with fishing activity and it is suspected that the damage was caused by a trawl wire. The Falconet arrived in Pembroke at 1700, 12th November, and all equipment was unloaded onto a pontoon. Ian Waddington and Keith Goy left Pembroke at 1745, arriving Bognor Regis 2400.

A.7 RMAS Warden Visit 13 Nov (317) and Shore Station Visit 17 Nov. (321) Keith Birch

A.7.1 General Notes

This data collection from the shipboard systems was carried out at the same visit as that to recover and refurbish the Sonic & buoy systems.

A.7.2 RMAS Warden Port Visit (317)

Sonic System

PC clock was 1min 5 seconds fast, with the clock corrected at 15:53 hrs. Storage media: both the optical and floppy discs were replaced with new discs.

MultiMet System

All three of the EPROM logger cards were replaced. The data was not spooled to disc, but will be replayed when the buoy has been deployed. The date and time were correct. Psychrometer 1073 deployed on the Port side was replaced by psychrometer 1065. A modified BASIC program, SHIPMET2, was created on the Sonic PC and contains the new psychrometer coeffs.

GPS and Compass Systems

Data floppy disc was changed. The program functionality was changed to record the full '1 minute' data set to the hard disc as well as the reduced '2 minute' dataset to floppy disc. To download the full data set will mean either using a Tape streamer or multiple floppy discs. The Fluxgate compass showed an error of 4 degrees high compared to the ships compass. The readings of the Fluxgate characteristics are : -
813 (8 - good calibration (ideally 9), 1 - poor location, 3 - number of calibration updates).

A.7.3 Shore station check 17/11/93 (321)

Using the buoy transmitter and Husky with data simulation program the last data file was closed on the Thorcom PC. This was considered important as it contains the wind data at the moment of capsize. The data was downloaded onto tape streamer, including data from 00:00hrs on the 7 November until 9 th November 14:02hrs. Although the tape streamer struggled repeating its recording several times on some data blocks all file transfers were verified by the software.

A.8 RMAS Warden and Shore Visit 21 - 23 Nov. (325 - 327) Robin Pascal

A.8.1 Personnel
Sunday - buoy and mooring preparation: C.Clayson, R.Pascal, K.Goy, & M.Hartman
Monday & Tuesday - buoy deployments: R.Pascal, K.Goy, and M.Hartman
Tuesday - hut visit: R.Pascal, K.Goy, and M.Hartman

A.8.2 Buoy and mooring preparation (325)

Arrived at Pembroke at 1015/325 to prepare Sonic and buoys and moorings for re deployment from WARDEN. After completion of the Sonic Buoy preparation, the farmers son was invited down to Pembroke Dock to see the buoy as he had shown an interest in doing so.

A.8.3 RMAS Warden Buoy deployment (326)

Operations

Equipment was loaded on WARDEN from 0800/326 and the ship sailed at 1045 hrs. We arrived on station at about 1330 hrs. The buoy was deployed first at location 51 29.68N 004 45.28W at 1350 hrs with no problems. Next the Sonic Buoy was deployed 300 x 400m from mooring at 1425 hrs, this also went successfully without any damage to sensors . The Pembroke buoy was deployed last, with its new flashing light at the location indicated by Margret's drawing. The flashing light had a 1 second flash rate but its visibility did not seem to be all that good. The mooring used, as I understand, has a reduced mooring and so the ship will not be able to moor to the buoy. Its only function is a navigation buoy to help protect the other moorings.

Weather

The wind was from the South East about force 1/ 2, there was a slight swell, and the conditions were sunny with a few cumulus clouds.

Measurements

The new SST soap was deployed at 1430 hrs continuously until 1645 hrs. Three bucket measurements were taken (Table) The ships SST from the engine room was taken at 15:35 about 12 deg. The ship was hove too from 14:30 to 15:15 and 16:00 to 16:45

TIME	TEMP
14:50	10.7
15:35	10.4
16:45	10.3

The times on the PC's was checked. The sonic PC was 18 seconds slow, and the GPS pc was 2 seconds slow. The MultiMet time was checked before sailing, which was incorrect. It gave 07/12/93 11:22:16 for a GMT time of 22/11/93 10:51:00. All times were corrected.The GPS fluxgate compass seemed to be within 5 degrees of the GYRO compass.

Data Down-loaded

All GPS data from day 316 to 326 both G and N prefix files; All SONIC PRN files from day 300 to 326; Replaced MWS floppy which had files from day 316 to 326; Raw data was left on optical disc. MultiMet data was left in eprom , the file was to big to down load via KERMIT.

MultiMet Temps			PRESS	SONIC		GYRO	FLUXGATE
	PORT	STBD		Chan.	Value		
WET	-2.127	-2.71	1024.7	U	-0.843	270	275
DRY	-2.19	-2.11		V	-27	102	106
				W	-0.131		
				REF	2.493		

A.9 RMAS Warden and Shore Station 21-23 Nov. (325 - 327) Keith Goy

A.9.1 Personnel

K Goy departed Middleton on Sea at 0700 21st Nov, collecting M Hartman at Crowthorne en route to Pembroke Docks arriving 1225 to meet C Clayson and R Pascal.

A.9.2 Mooring assembly (325)

All mooring components were assembled P.M 21-11-93. The intention was to modify the Sonic Buoy's performance by incorporating a 200 Kg ballast weight 1 m below the buoy suspended by 3 x 1 3mm chain strops. The towing bridle was increased in length and modified to tow horizontally, this was achieved by supporting the towing bridle and surface line with two large inflatable buffs.

A.9.3 Redeployment of Sonic and buoys (326)

Equipment loading onto RMAS Warden commenced 0800 22-11-93. During loading of the Sonic Buoy, the 13mm chain strops were adjusted to allow the ballast to act through the centre of the buoy. Warden sailed at 1130 approx and mooring operations commenced at 1350 on the mooring site with the deployment of the followed by the Sonic Buoy. Mooring operations were straight forward and were completed by 1425. Prior to deployment Argos transmissions were confirmed with the Gonio test set. Ship's staff from the Warden then deployed a marker buoy on site which was completed at 1545.

Warden remained on site to check the mooring performance of all buoys and the operation of flashing lights. Argos IDs were checked; the Marine Physics Met buoy was still transmitting but the platform ID was still incorrect and showing errors in the record length. Warden sailed for Pembroke arriving at 1910 approx. All equipment was unloaded and stored in the shed provided.

A.9.4 Shore Station Visit (327)

The hut at Manorbier was checked at 0915 by R Pascal. K Goy and M Hartman. Attempts to raise the antenna mounting mast was complicated by the freezing temperatures. The pump was eventually thawed out using hot water and the mast raised and stayed.

Personnel departed the hut to travel back to IOS at 1130.arriving at 1700 23rd.

A.10 Shore Visit and RMAS Warden 3 - 5 Dec. (337 - 339) Margaret Yelland

A.10.1 Pembroke Dock, & RMAS Warden Port visit (337)

Departed JRC 0830/337, arrived Pembroke Dock 1230. Explained urgency of Sonic Buoy recovery to Morgyn Davies, and discussed ship availability. The Warden was available for that weekend (4-5th) and probably for the following weekend (11-12th). The weather forecast was unpromising, the best day being Sunday 5th with a forecasted force 4 to 5 West or Northwest wind. It was decided to sail at midnight on Saturday in order to be on station gathering a few hours of rough weather ship data before attempting the mooring recovery. Boarded Warden 1400 to back up data and check systems.

SONIC SYSTEM

Display of log PSD vs. windspeed looked OK. System stopped 1410. *PRN and *MWS files to day 336 backed up to both floppy and optical disks. There was no *PRN file for day 334. Confirmed raw sonic data was recording to optical. Clock was 15 seconds slow, not changed.

GPS & COMPASS SYSTEM

Display had lost the needle and was not showing any positions etc. Error on display was "communications buffer overflow in 1420DAT". System stopped 1430. Backed up G*DAT and N*DAT files to floppy. No N323*DAT file present. Compass damping = 4; "Quality" string = 715. Clock was OK. After rebooting by ctrl+alt+del, the system started logging OK. The compass showed a heading of 148 degrees, which was in agreement with the ship's gyro reading of ~140 degrees (allowing for magnetic variation).

MULTIMET

No data backed up since the file is too big. The date and time were OK. Real-time data readings (using Shipmet2):-

u = -1.518, v = -27.2, w = -0.536, ref = 2.49,

pwet = 10.61, pdry = 10.88, swet = 10.04, sdry = 10.63,

press = 1008, (sst not connected)

No setup information was obtained due to error in instructions. Restarted Sonic system about 1750. Started logging OK. Left Warden ~1630.

A.10.2 Shore Station Visit (338)

Arrived at land station 0930/338. HF data logging OK. System stopped ~1000. Backup to tape began. Forgot to check clock before commencing backup, but after one or two minutes into the backup, the display showed a time which was one minute fast. Two tapes needed for backup, which took until 1500 to complete since there were repeated "verify" failures and accompanying re-writes. Hard disk had ~79.5 Mbytes free (i.e. enough for 4 days at 0.19 Mbytes per 15 minutes), so no data was deleted. Clock was corrected and system restarted ~1515.

The mast had begun to telescope down slightly, so re-tightened stays. Purchased PVC tape and adjustable spanner (embryonic JRC met team tool kit).

A.10.3 RMAS Warden Charter (338 - 339)

Arrived at Pembroke dock 2200/338, and joined Nick Crisp, Keith Goy and Robin Pascal who had driven from Wormley that afternoon. Had to haggle with person manning the dock gates in order to get the key to the hangar, despite assurances from Morgyn Davies that access would be arranged. Mooring equipment was taken from hangar to Warden. The mooring cradles had been placed on the aft deck during the day. The psychrometer bottles were topped up and the motors checked.

When the Warden went over from shore to ship power all systems were again checked and were functioning OK. The Multimet system setup was checked (using SETUP rather than STATUS); bits=68, extra chips=0, boards=3. Data was being logged to the Eprom. Clock set correct at 23:51.

Warden sailed at 0000/339, arriving on station at ~0240. Warden stayed hove-to on station until 0800, at which time it was decided to return to Pembroke since the forecast showed no chance of any improvement in the conditions. The windspeed throughout had been about 10m/s, from the West or Southwest. The sea state made it impossible for any attempt at either mooring recovery or placing a backup Argos beacon on the Sonic Buoy. No work on deck was carried out. The ship's master ruled out an inspection tour of the moorings before heading back to port, due to fears about going beam-on to the sea. Sonic and GPS data were backed up during the return passage. The Warden arrived at Pembroke Dock about 1030. Nick Crisp, Keith Goy and Robin Pascal left the dock at 1115 and arrived at home at 1530.

A.10.4 Shore Station Visit (339)

Arrived at the land station about 1200/339, to find that HF reception had ceased at 2100/338 (Saturday evening), so did not attempt to raise the mast. Left system switched on. Returned to B&B in Tenby to retrieve gear. Left Tenby 1300, arrived at JRC to unload gear and swap cars at 1700.

A.11 RMAS Grasmere 6/7 Jan 94 (006 - 007) Keith Goy

A.11.1 Personnel

K Goy departed Institute in Bedford van 1330 6th to travel to Tenby arriving 1735. Picked up keys from Guest House and contacted RMAS Grasmere by cell phone.

A.11.2 RMAS Grasmere - recovery (006/94)

Picked up by Gemini from Tenby Beach and joined Grasmere at 1810. Steamed out to mooring site arriving 1950. Flashing lights observed and VAESAT identified by spotlight. identified further to Starboard and the polo float supporting the joint of the two rubber bungees seen floating on the surface at slack water. This was grapnelled from the starboard bow and the joint hauled onboard to be split. During disconnection, tension in the lower bungee increased so Grasmere was repositioned in order to relieve the tension and allow the recovery to continue. The joint was split and the Dhan Buoy (50 gallon drum) made ready to attach to the mooring riser line. It then became apparent that at some stage the lower rubber bungee had broken and we were able to haul this easily onboard. The upper bungee was hauled in and the allowed to drift across the bows for recovery from the port side using the Derrick. Once onboard the rig was examined and it was suspected that the lower bungee had pulled out from its lower attachment, this was confirmed later at IOSDL. Attempts were made to identify and confirm the integrity of the remaining rigs however only the VAESAT light was visible and it was not possible to sight the others with the spotlight. Grasmere departed the site at 2030/006 arriving Pembroke docks at 0030/007. K Goy travelled back to Tenby to pick up the van by taxi arriving back at 0200. 0800/007 Travelled to Pembroke Docks to pick up. 1700/7 Arrive back at IOSDL.

A.12 RMAS Warden 17 Jan. 94 (017/94) Robin Pascal

A.12.1 Personnel

R. Pascal, K. Goy , N. Crisp

A.12.2 On Board Systems Check (017/94)

Before sailing the on board systems were checked out. The GPS system had hung with a Communications buffer overflow error. The system was re booted at 0931/017 and ran correctly. The Sonic system was working with no error messages displayed. At 0957 the Sonic system was halted to check out the MultiMet sytem.

Reset MultiMet at 0958/017, output was :- 0093020609553600 (i.e date 06/02/93 time 09:55:36 - Note incorrect year is a fixed software value). Date and time reset at 10:00:50 MultiMet output :- 0093011710005100 (i.e. date 01/17/93 time 10:00:51 which is correct apart from year).

Checked eprom logger setup: Boards=2; Chips=0; BPR=68; NEFA=3FFFCE (therefore Eprom logger out of memory).

MultiMet data check

Temps	WET	DRY
Port	3.5	4.0
Stbd	3.5	4.1
Press	1029.7	
SST	n/c	

1215 Started logging Multimet data on Sonic PC.

1220 SST deployed .

1252 Stopped logging MultiMet data. Re booted Sonic PC.

1345 Ship anchored head to wind.

1526 Stopped Sonic PC and started logging MultiMet .

1720 Recovered SST sensor.

2030 Stopped logging MultiMet

A.12.3 RMAS Warden - Mooring Recoveries (017/94)

Warden sailed from Pembroke at 0930/017. Arrived at station at 1215 GMT, wind force 2 / 3 and dropping some swell, low water at 1500 hrs

Met Buoy Mooring

Initial attempts to recover mooring were by backing the ship up to the buoy against the tide and using the Z boat to attach a recovery line to the buoy. The ship managed to get within 10 meters of the buoy but as the load increased on the recovery line the buoy was forced below the surface. The recovery line was released and the buoy re surfaced and this method was abandoned.

The ship then attempted to drop anchor up tide of the buoy and ease down to the mooring. In the first attempt the anchor failed to hold; second attempt the ship was misaligned with the tide and buoy. On the third attempt the ship was positioned well and the recovery commenced at 1400 hrs. Met Buoy on board at 1420, at 1420 initial load was put on mooring to recover subsurface components but the sphere appeared and the mooring went slack. Sphere and first current meter were recovered, the mooring line showed that the second current meter had failed at the termination. Anchor and current meter were left on bottom for later salvage.

VAESAT

Mooring recovery started at low tide at 1500 hrs, therefore no need to anchor. The Z boat was sent to attach recovery line and the buoy was hauled in . Buoy on deck at 1515 hrs with S4 current meter. 1525 anchor for mooring was hauled on deck. During recovery of VAESAT, pellet floats from the second Sonic Buoy mooring and the third mooring were seen on the surface. The Z boat was deployed to attach additional floats to hold the moorings on the surface so they could be recovered.

Sonic Buoy Mooring

Recovery of the subsurface components of the second Sonic Buoy mooring started at 1535 hrs, anchor on deck at 1550 hrs.

Mooring

Recovery of the subsurface components of the third mooring started at 1600 hrs , anchor on deck at 1620 hrs.

Pembroke Buoy

During the recovery of the other moorings the Pembroke buoy, which had moved from its original site, was sighted approximately three miles north of the array. On completion of the other recoveries the ship sailed to the new position. Recovery of the buoy was started at 1710 and completed by 1720. The day light had now gone so no further recoveries were attempted and the ship steamed for port. The ship docked at Pembroke at 2030 hrs.

APPENDIX B. REPORT ON SONIC BUOY TRIAL DEPLOYMENT - APRIL TO MAY 1993

P.K.Taylor, R.W.Pascal, K.G.Birch, C.H.Clayson, M.J. Yelland
July, 1993

B.1 Aim

The main aim of the trial was to check that the buoy would remain moored and up-right in the sea conditions likely to be encountered during the autumn 1993 Carmarthen Bay experiment "SWALES". Data were gathered to check the calculations on buoy motion under different sea conditions. The buoy was equipped with a Young propeller-vane anemometer, the Buoy Motion Package (BMP), the Formatter, and Meteosat and Argos transmitters. A "Black Box" system was used to selectively record data when the wind conditions were within preset values or if the buoy had come near to capsizing (or had capsized). The buoy was deployed at Site A, the planned position of the SWALES mooring array (51° 29.5'N 4° 45'W) using the MOD ship, the "Warden" operating out of Pembroke dock.

B.2 Deployment

B.2.1 Conditions

Time: 14:50 BST 13/4/93 (day 103)
Tide: 1 - 1.5 Knots to West (Ebbing); High tide 11:49 BST at Swansea; Water Depth: 42 m.
Wind: 5-10 Knots increasing to 10-15 Knots; Wind direction easterly.

B.2.2 Method

The ship was anchored head to wind and tide, so that the propeller could be stopped. The Buoy was deployed first, using a quick release hook and streamed away with the tide. The mooring was fed out to its full length and then the anchor was let go. The ship remained by the buoy until 16:30 BST.

B.3 Conditions during the trial period

The buoy remained deployed for 39 days. The table shows the times and mean wind values for the data recorded. The winds refer to the 3m measurement height of the buoy and should be multiplied by a factor of about 1.2 to obtain the equivalent 10m wind. The lower wind speed data bins were filled first and no further recording then took place until higher winds were encountered during the final week of the trial. The maximum peak wind during the period was 21 m/s.

B.4 Recovery

B.4.1 Conditions

Time:11:00 BST 22/5/93 (day 142)
Tide: 2 Knots to West
Wind: 0-5 Knots; Wind direction South Easterly.

B.4.2 Method

The ship was anchored upwind and tide of the buoy so that the stern was approximately over the buoy anchor. The Z-boat was launched so that the sensors could be removed from the buoy before recovery and also to attach a line from the ship to the buoy. The buoy was then winched into the stern of the ship and brought on board. The mooring was the winched in and the anchor released from the bottom without any problems although the anchor weight appeared near the limit for the mooring line. After recovery the mooring and buoy looked to still be in good condition , with no obvious wear.

Day	Time	Mean wind speed m/s	Day	Time	Mean wind speed m/s
103	1200	1	107	1800	5
103	1500	8	107	2100	6
103	1800	5	134	2100	10
103	2100	3	135	0000	10
104	0000	4	136	1500	12
106	0300	5	136	2100	10
106	1500	6	137	0000	10
106	1800	7	137	0300	11
106	2100	7	137	0600	10
107	0000	6	137	2100	12
107	1200	6	138	0000	12
107	1500	6			

B.5 Summary

The trial was a success. The buoy was deployed and recovered without damage. The buoy remained deployed and working for the duration of the trial. Although very high winds were not encountered the buoy survived near-gale to gale force winds during the final week of deployment.

Natural
Environment
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Council